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AD NUMBER
ADB063399
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AD B063399

AFRPL-TR-81-25

82-0706

COMBUSTION RESPONSE CALCULATIONS FOR COMPOSITE SOLID PROPELLANTS

Volume II.

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December 1981

Final report for the period February 1978 through February 1980

Prepared for

AIR FORCE ROCKET PROPULSION LABORATORY
DIRECTOR OF SCIENCE AND TECHNOLOGY
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FOREWORD

This report was submitted by the School of Aeronautics and Astronautics, Purdue University, West Lafayette, Indiana, 47907, under Contract F04611-78-C-0025, Job Order No. 2308M1DG with the Air Force Rocket Propulsion Laboratory, Edwards AFB, California 93523.

Volume I presents the results of a research program for determining the combustion response functions for a multimodal polydisperse composite propellant. Volume II is a User's Manual for the computer program, PEM, and is available on request. The co-principal investigators for the program were J. P. Renie and J. R. Osborn.

This technical report is approved for release and distribution in accordance with the distribution statement on the cover and on the DD Form 1473.

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Citation Format: Full Citation (1F)

Accession Number:
ADB063399
Citation Status:
Active
Citation Classification:
Unclassified
SBI Site Holding Symbol:
ADD, NRL, NWC NRL NWC
Fields and Groups:
210200 - Combustion and Ignition
210902 - Solid Rocket Propellants
Corporate Author:
PURDUE UNIV LAFAYETTE IN SCHOOL OF AERONAUTICS AND ASTRONAUTICS
Unclassified Title:
(U) Combustion Response Calculations for Composite Solid Propellants. Volume II. User's Manual.
Title Classification:
Unclassified
Descriptive Note:
Final rept., Feb 78-Feb 80,
Personal Author(s):
Renie, J P
Osborn, J R
Report Date:
Dec 1981
Media Count:
136 Page(s)
Cost:
$14.60
Contract Number:
F04611-78-C-0025
Report Number(s):
AFRPL-TR-81-25-VOL-2
Project Number:
2308
Task Number:
M1
Monitor Acronym:
AFRPL
Monitor Series:
TR-81-25-VOL-2
Report Classification:
Unclassified
Supplementary Note:
See also Volume 1, AD-B062 847L.

Distribution Statement:
Approved for Public Release; Distribution Unlimited.
Descriptors:
(U) *COMPOSITE PROPELLANTS, *SOLID PROPELLANTS, *COMBUSTION, *RESPONSE, USER MANUALS, COMPUTATIONS, COMPUTER PROGRAMS, STEADY STATE, PARAMETERS, SUBROUTINES, SAMPLING
Identifiers:
(U) Nonsteady state, WUAFRPL2308M1DG, PE61102F.
Identifier Classification:
Unclassified
Abstract:
(U) Volume II is a user's manual for computer programs written to perform theoretical analyses described in Volume I. This volume describes the main routines and subroutines used in the analysis of the combustion of composite solid propellants both steady state and nonsteady state. Also, a detailed description of the input parameters required as well as the output generated is presented. Sample cases are provided to facilitate understanding of the programs so described. (Author)
Abstract Classification:
Unclassified
Distribution Limitation(s):
01 - APPROVED FOR PUBLIC RELEASE
Source Serial:
F
Source Code:
291850
Document Location:
DTIC AND NTIS
Change Authority:
941004 - Public release drct'd by MSgt P.B. Adkinson, Supt Tech Svcs Div., OLACPL/TSR, Edwards AFB, CA, via ltr dtd 8 Sep 94.

Unclassified
SECURITY CLASSIFICATION OF THIS PAGE (When Data Entered)

REPORT DOCUMENTATION PAGE		READ INSTRUCTIONS BEFORE COMPLETING FORM
1. REPORT NUMBER AFRPL-TR-81-25	2. GOVT ACCESSION NO.	3. RECIPIENT'S CATALOG NUMBER
4. TITLE (and Subtitle) COMBUSTION RESPONSE CALCULATIONS FOR COMPOSITE SOLID PROPELLANTS. Volume II.		5. TYPE OF REPORT & PERIOD COVERED Final Feb 1978 - Feb 1981 6. PERFORMING ORG. REPORT NUMBER
7. AUTHOR(s) Renie, J. P. Osborn, J. R.		8. CONTRACT OR GRANT NUMBER(s) F04611-78-C-0025
9. PERFORMING ORGANIZATION NAME AND ADDRESS School of Aeronautics and Astronautics Purdue University West Lafayette, Indiana 47907		10. PROGRAM ELEMENT, PROJECT, TASK AREA & WORK UNIT NUMBERS 2308M1DG
11. CONTROLLING OFFICE NAME AND ADDRESS Air Force Rocket Propulsion Laboratory/DYC Edwards AFB, CAlifornia 93523		12. REPORT DATE December 1981 13. NUMBER OF PAGES 133
14. MONITORING AGENCY NAME & ADDRESS(if different from Controlling Office)		15. SECURITY CLASS. (of this report) Unclassified 15a. DECLASSIFICATION/DOWNGRADING SCHEDULE

16. DISTRIBUTION STATEMENT (of this Report)
Distribution limited to U.S. Government agencies only; Test and Evaluation, Dec 1981. Other requests for this document must be referred to AFRPL/TSPR (STINFO), Stop 24, Edwards AFB, California 93523.

17. DISTRIBUTION STATEMENT (of the abstract entered in Block 20, if different from Report)
Approved for public release; Distribution unlimited.

18. SUPPLEMENTARY NOTES

19. KEY WORDS (Continue on reverse side if necessary and identify by block number)
Combustion
Combustion Instability
Response Functions
Combustion Response

20. ABSTRACT (Continue on reverse side if necessary and identify by block number)
Volume II is a user's manual for computer programs written to perform theoretical analyses described in Volume I. This volume describes the main routines and subroutines used in the analysis of the combustion of composite solid propellants, both steady state and nonsteady state. Also, a detailed description of the input parameters required as well as the output generated is presented. Sample cases are provided to facilitate understanding of the programs so described.

DD FORM 1 JAN 73 1473 EDITION OF 1 NOV 65 IS OBSOLETE

Unclassified
SECURITY CLASSIFICATION OF THIS PAGE (When Data Entered)

SECURITY CLASSIFICATION OF THIS PAGE(*When Data Entered*)

SECURITY CLASSIFICATION OF THIS PAGE(*When Data Entered*)

TABLE OF CONTENTS

TABLE OF CONTENTS (continued)

ABSTRACT

Volume II is a user's manual for computer programs written to perform theoretical analyses described in Volume I. This volume describes the main routines and subroutines used in the analysis of the combustion of composite solid propellants both steady and nonsteady state. Also, a detailed description of the input parameters required as well as the output generated is presented. Sample cases are provided to facilitate understanding of the programs so described.

LIST OF FIGURES

I. INTRODUCTION

A computer program has been developed for determining both the steady state and the nonsteady state response for a AP-based composite solid propellant. The theoretical combustion model is a multiple flame type model similar in many respects to the original Beckstead, Derr and Price (BDP) model. However, this model, the Petite Ensemble Model, or PEM, is unique in that it has the capability of representing the actual oxidizer particle size and size distribution of the propellant formulation within the burning rate calculational framework. The PEM has been modified to include a comprehensive aluminum particle model as well as an in depth erosive burning model. The aluminum model is based upon a mechanistic scenario of the aluminum particle behavior during the regression of the propellant surface, or burning. That is, the behavior of the aluminum particle is modeled from its emergence at the propellant surface, its flight away from the surface under the influence of viscous forces, its subsequent ignition and combustion within the hot gas stream above the surface, to its energy release due to combustion, some of which being transferred back to the propellant surface. It is this possibility of energy feedback to the propellant surface which allows the aluminum to affect the overall burning rate characteristics of the propellant under investigation. The erosive burning model is based on the concept that a turbulent boundary layer is formed above the burning propellant surface due to the presence of a crossflow velocity. It is due to this turbulent boundary layer that the gas phase transport properties are enhanced above their respectively molecular values. This is the mechanism within the erosive burning PEM which accounts for increased burning rates, or erosive burning, in the presence of a crossflow of gas above the propellant surface.

In terms of nonsteady state combustion modeling, various pressure coupled and velocity coupled response models have been incorporated in the statistical PEM framework. The two primary nonsteady state response modeling efforts have been a small perturbation analysis and a Zeldovich/Novozhilov technique. In both cases, the nonsteady state behavior of the solid propellant is described in terms of steady state responses to various changes in combustion variable such as pressure, crossflow velocity, initial solid propellant temperature and surface temperature. Both the steady state and nonsteady state theoretical analyses upon which the computer program described herein is based is presented in the final report of this contract under separate cover.

This report presents a discussion of the computer program organization, a description of the various subroutines, a discussion of the input parameters, a brief interpretation of the output information and a number of sample cases to illustrate the various steady state and nonsteady state applications of the computer program.

II. PROGRAM ORGANIZATION

A. INTRODUCTION

In this section, the computer program overlay structure is presented along with a detailed discussion of the various calculational options afforded by the PEM computer program. Also, some general comments are made concerning the computer program input, parameter initialization and output.

B. CALCULATIONAL OPTIONS

The framework upon which this computer program is based is a comprehensive version of the theoretical, multiple flame combustion model described earlier. This model, designated as the PEM, is a unique model in that the propellant's oxidizer particle size and size distribution can be specified. Using this model, steady state combustion parameters such as burning rate, pressure exponent, temperature sensitivity and erosive burning enhancement can be calculated. In such a manner, these parameters will depend on the actual oxidizer particle size and size distribution within the propellant formulation. Therefore, the basic core of the computer model is the calculation of the steady state burning rate of a propellant with a specified oxidizer distribution. If the propellant under consideration contains aluminum particles, these metal particles are subjected to a rigorous analysis. Such an analysis determines the behavior of the aluminum particles as they first emerge from the propellant surface, flow away from the surface due to viscous drag, and subsequently ignite and burn in the hot gas stream above the propellant surface. In the process of burning, heat is liberated some of which may be transferred back to the propellant surface thus contributing to the combustion mechanism of the surface regression.

If a crossflow velocity is assumed to be present above the burning propellant surface, then the erosive burning module of the computer program is entered and the nonerosive burning rate of the propellant is enhanced by an amount dependent on the transport property enhancement caused by the turbulent boundary layer above the propellant surface.

Having calculated the steady state burning rate of a propellant formulation in question, the computer program has the option to calculate both the pressure coupled or the velocity coupled response functions. Various nonsteady state response models can be used to calculate the desired nonsteady state response, the selection of the particular model being specified by the user. Finally, the nonsteady state response is calculated and presented as a function of the frequency of the nonsteady driving mechanism, be it pressure or velocity field oscillations.

As a final measure, the user has the option to specify whether or not the response function versus frequency data generated should be represented as a plotted curve. A detailed plotting routine has been incorporated into the PEM computer program. This plotting routine contains many of the standard CALCOMP calls and should be compatible on most systems. However, the user maintains the option to substitute his own plotting routines if so desired.

C. PROGRAM OVERLAY STRUCTURE

The overall computer program consists of sixty-three routines (four program routines and fifty-nine subroutines). In order to minimize the amount of central memory required to load and run the computer program, a standard overlay scheme is employed. This overlay structure is presented in Figure 1. Two levels of overlaying are employed: the resident overlay level and the primary overlay level. OVERLAY (PEMO,0,0) is the resident overlay and it controls the overall execution of the computer program. In this overlay, all the steady state combustion modeling is performed except for the erosive burning calculational schemes. The steady state multiple flame modeling within this overlay contains the detailed aluminum modeling previously described. If a crossflow velocity above the propellant surface is present, then the first primary overlay, OVERLAY (PEM1,1,0) is called after the steady state non-erosive burning rate is calculated. Also, if nonsteady state pressure coupled or velocity coupled response calculations are desired, the second primary overlay, OVERLAY (PEM2,2,0), is called. It is within this overlay that the various nonsteady state response models are employed at the user's option in order to calculate the pressure coupled or velocity coupled response of the propellant formulation under consideration. Finally, after calling this overlay to perform the nonsteady state response calculations, the third and final primary overlay, OVERLAY (PEM3,3,0), can be called in order to plot the nonsteady state response results.

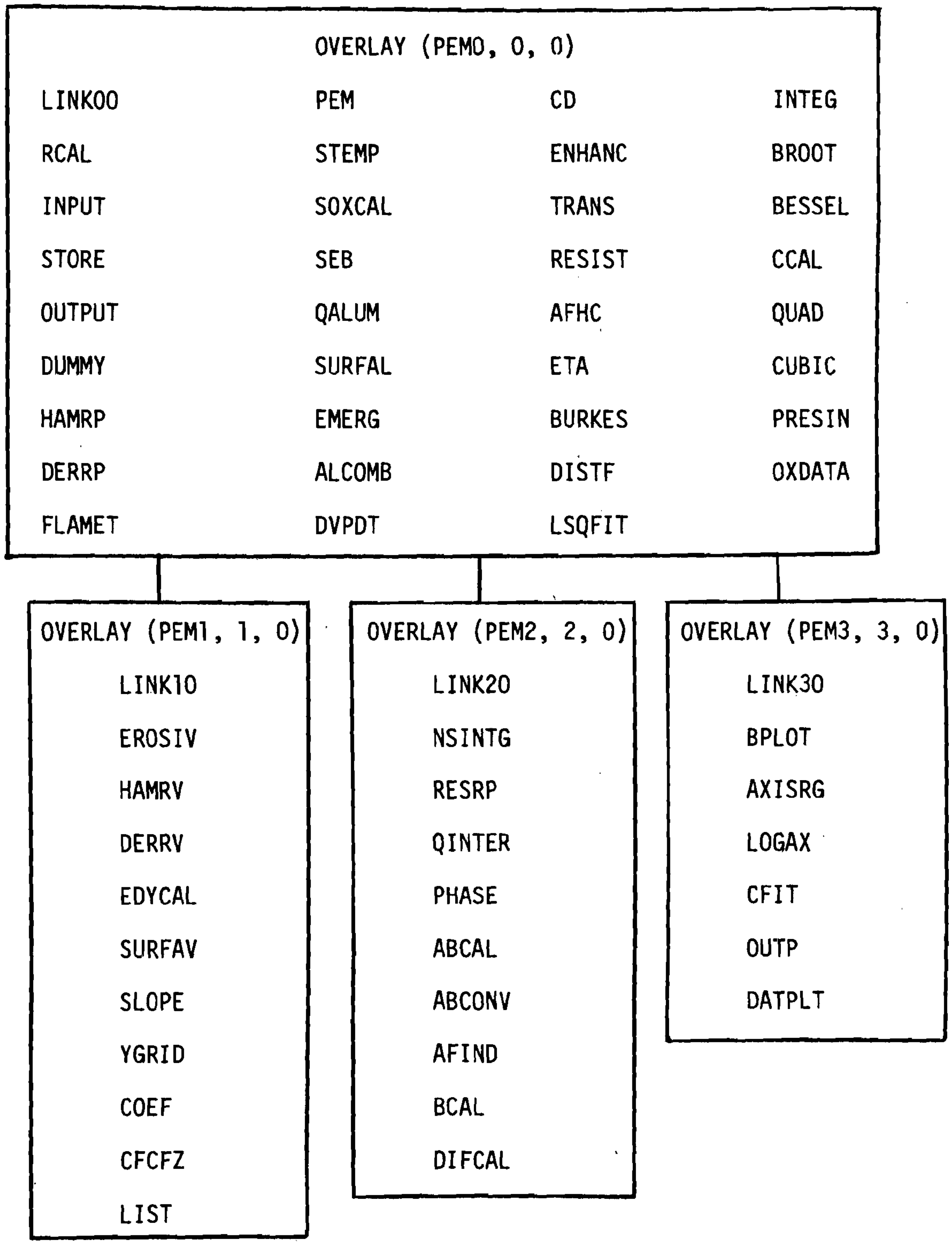

Figure 1. Program OVERLAY Structure

D. DATA INPUT

The input data for the computer program are entered through both namelist input and formatted read statements. The formatted read statements are only used in the plotting portion of the computer program. For the major modeling portion of the computer program, seven namelists must always be specified: namelists FLAG, PARMST, PROPDT, ALUMDT, EROSDT, RESPDT, and OXDIST. Namelist FLAG enters various control parameters for the steady state modeling portion of the program. Namelist PARMST contains parameters pertaining to the numerical analyses within the computer programming. Also, external environmental conditions such as the combustion pressure and the initial solid propellant temperature are specified through this namelist grouping. Namelist PROPDT contains parameters pertaining to the actual propellant formulation being considered. That is, the various oxidizer, fuel, and non-aluminum additives solid phase and gas phase properties are specified through this namelist. Namelist ALUMDT contains parameters related to the aluminum particle combustion modeling within the program. Various aluminum properties and program control parameters are specified through this namelist. Namelist EROSDT contains parameters related to the erosive burning modeling methodologies. The value of the crossflow velocity is entered through this namelist grouping. A non-zero value for this crossflow velocity directs the flow of the program into the erosive burning portion of the computer program. Namelist RESPDT contains parameters related to the nonsteady state modeling performed by the computer program. Control variables are entered into this namelist to direct the type of pressure coupled or velocity coupled response calculation to be performed. Finally, the last namelist, OXDIST, specifies the actual oxidizer particle size distribution of the propellant formulation being considered.

E. OUTPUT

Each of the four program routines; LINK00, LINK10, LINK20, and LINK30, controls a portion of the overall output corresponding to the calculations performed within each of the program routines. The steady state calculations are outputed through the LINK00 routine, the erosive burning results are directed through the LINK20 routine, the nonsteady state response results are directed through the LINK20 routine and the output corresponding to the plotting results is directed through the LINK30 routine. However, some of the intermediate results are directed from many of the other subroutines within the program. The actual type of output provided will be discussed further when the many sample cases are presented. Primarily, the output consists of the input parameters, any intermediate calculational results, the final pseudo-propellant burning rates, both nonerosive and erosive, and the nonsteady state pressure coupled and velocity coupled response functions as functions of driving frequency.

III. SUBROUTINE DESCRIPTIONS

A. INTRODUCTION

In this section, a brief description is given of the function of each of the subroutines comprising the overall computer program. This information supplements the information available in the form of comment statements within the program listing available upon request from AFRPL. The many variables not detailed in the namelist input discriptions of Section IV will be described to aid in the discussion of the output presented for the many sample cases provided.

B. OVERLAY (PEMO,0,0)

LINK00. This program routine is the main control routine in OVERLAY (PEMO,0,0), the resident overlay. From this routine, INPUT is called which directs the input of the seven namelist and provides the LINK00 routine with information as to what calculations are to be performed. Much of the program output is either generated from this routine or directed to the main output subroutine, OUTPUT. Also, the erosive burning routine, LINK10, the nonsteady state response routine, LINK20, and the plotting routine, LINK30, are called from this routine based upon the information provided through the namelist input groupings. At the end of this routine, the program has the capability of reading another case after storing any pertinent information in STORE or stopping altogether. As before, such control information is read in through the various namelist input groupings.

RCAL. This subroutine stores the pseudo-propellant burning rates during the course of the steady state calculations. Then, with the combustion model having calculated and stored the burning rate for each pseudo-propellant comprising the overall polydisperse propellant, this routine is again called and the overall propellant burning rate is calculated. This task is performed via an integration over all oxidizer particle sizes of the pseudo-propellant burning rates weighted by an oxidizer distribution function. IKING is a control variable within this subroutine causing the following results:

If IKING equals 0, a series summation technique is utilized to calculate the overall propellant burning rate from the pseudo-propellant information.

If IKING equals 1, a parallel summation technique is utilized to calculate the overall propellant burning rate from the pseudo-propellant information.

If IKING equals 2, a combination of the two schemes is performed; half series and half parallel summation.

If IKING equals 3, the user can specify the combination method employed. In the current version of the computer program, the percentage of each summation scheme is determined by a BETAR parameter, being calculated from the oxidizer distribution/pseudo-propellant burning rate data.

<u>INPUT</u>. This subroutine's primary function is to initialize and read the seven namelist input groupings; FLAG, PARMST, PROPDT, ALUMDT, EROSDT, RESPDT, and OXDIST. In addition to reading these namelists, the two oxidizer integration diameter arrays, D(55) and XD(541), and their respective oxidizer distribution function arrays, FSKP(55) and XFSKP(541), are generated from the oxidizer particle size distribution data provided. The following parameters are also calculated based on the input propellant formulation data:

XALFA	the overall propellant oxidizer mass fraction.
XNUT	the overall propellant oxidizer volume fraction.
RHOT	the overall propellant density.
C	the proportionality factor in the volume of fuel binder to volume of oxidizer (see CCAL).
ALFAV(55)	an array of pseudo-propellant oxidizer mass fractions.
XNUV(55)	an array of pseudo-propellant oxidizer volume fractions.
RHOV(55)	an array of pseudo-propellant densities.

One should note that if the oxidizer diameter exponent, XN, equals three, each of the elements in the above three arrays are equal to XALFA, XNUT, and RHOT, respectively, that is, the pseudo-propellant properties are equal to the overall propellant properties.

STORE. This subroutine is called initially from OUTPUT (INDEX=1) to store intermediate burning rate versus pressure theoretical and experimental data for a particular propellant formulation. It is called again from OUTPUT (INDEX=2) to store series and parallel summation theoretical burning rate information for each propellant. Finally, the subroutine is called a third time from LINKOO (INDEX=3) to direct the output of all the results for a series of propellants in order to investigate the theoretical versus experimental comparison for both burning rate and pressure exponent. Average percent errors are calculated and presented for each comparison. Once again, various series and parallel combinatory summation schemes can be employed via the IKING control parameter discussed above in RCAL.

OUTPUT. This subroutine outputs the many variables that are read into the computer program through the namelist input commands as well as the results of the steady state burning rate versus combustion pressure calculation for the propellant formulation under investigation. This subroutine stores the burning rate versus pressure data for NPRESS pressure values and then calls subroutine LSQFIT which performs a linear least square fit of the data. The results of such a calculation, the pressure exponent and a goodness of fit correlation coefficient, are then outputed.

DUMMY. This subroutine is a dummy subroutine used to load the binary read and write instructions. This procedure is required in order

for the computer program to run utilizing the FTN4 compiler version currently available at the Purdue University Computing Center (PUCC). This routine may not be necessary for other users at other computing facilities.

<u>HAMRP</u>. This subroutine directs the program flow for the nonsteady state pressure coupled response using the small perturbation method. The nonsteady state pressure coupled response is not calculated in this subroutine; this function is performed in the routine LINK20. However, the perturbation of the steady state model equations is performed whenever the control parameter, IRPHM, equals one. For each pseudo-propellant, the combustion pressure and surface temperature is perturbed systematically within the framework of the steady state burning rate calculations and the various f parameters, referred to in the theoretical analysis portion of the final report of this contract under separate cover, can be calculated and stored for future use in LINK20. From the values of the f parameters thus calculated, four parameter arrays, C(55,1), C(55,2), C(55,3) and C(55,4), can be generated. Also, the zero frequency limit of the pressure coupled response function, the pressure exponent array, PXN(55), can be filled.

<u>DERRP</u>. This subroutine directs the program flow for the nonsteady state pressure coupled response using either the method of Denison and Baum or the Zeldovich/Novozhilov method. The nonsteady state pressure coupled response is not calculated in this subroutine; this function is performed in the routine LINK20. However, the steady state d parameters, referred to in the theoretical analysis portion of the final report of this contract under separate cover, are calculated via a systematic perturbation of the combustion pressure and the initial solid propellant

temperature. The following steady state combustion parameter arrays thus calculated are as follows. The corresponding d parameter designation is also given where applicable.

PXN(55) an array of pseudo-propellant pressure exponents (d_1).

PXM(55) an array of values related to the pseudo-propellant's sensitivity of surface temperature to changes in combustion pressure (d_3).

PXK(55) an array of values related to the pseudo-propellant's sensitivity of burning rate to changes in initial solid propellant temperature (d_2).

PXS(55) an array of pseudo-propellant temperature sensitivities.

PXR(55) an array of values related to the pseudo-propellant's sensitivity of surface temperature to changes in the initial solid propellant temperature (d_4).

PXD(55) an array of pseudo-propellant properties ($d_1 d_4 - d_2 d_3$).

Once these steady state combustion parameters are calculated, the following variables are also calculated for later use in the nonsteady state response calculations:

AV(55) an array of pseudo-propellant Denison and Baum A parameters via the pressure perturbation scheme (d_1/d_3).

AVV(55) an array of pseudo-propellant Denison and Baum A parameters via the initial solid propellant temperature perturbation scheme (d_2/d_4).

BV(55) an array of pseudo-propellant Denison and Baum B parameters ($1./d_2$).

ES1(55) an array of pseudo-propellant effective surface activation energies via the pressure perturbation scheme.

ES2(55) an array of pseudo-propellant effective surface activation energies via the initial solid propellant temperature perturbation scheme.

FLAMET. This subroutine computes flame temperatures and molecular weights of the flame combustion products based upon calculations previously performed with the NASA Thermochemistry Program. The adiabatic flame temperatures and molecular weights have been calculated at three separate values of combustion pressure; 34.0136, 68.0272 and 136.0544 atmospheres. Also, calculations have been performed for various oxidizer mass fractions from zero to one in increments of .05 for two types of fuel binder; HTPB (IFUEL=1) and PBAN (IFUEL=2). Therefore, by means of piecewise curve fitting of such data, the flame temperature and molecular weight can be calculated as a function of fuel type, oxidizer mass fraction and combustion pressure. The oxidizer is always considered to be ammonium perchlorate (AP). If the control parameter, ITFAD, equals one, then the curve fits are based on the temperature and molecular weight data inputed through the namelist PROPDT. The adiabatic flame temperature and the molecular weight for the oxidizer monopropellant flame combustion products are also calculated as functions of pressure. Finally, the two flame temperatures are corrected for initial solid propellant temperature other than 294.15 K for which the data has been determined.

PEM. This subroutine controls the steady state burning rate calculation. This subroutine is called from any of the burning rate calculational control routines; LINKOO, DERRP, HAMRP, EROSIV, HAMRV, or DERRV, returning with a value of burning rate, R. This value of burning rate is equal to the planar surface mass flux, MT, divided by the total propellant density, RHOT.

STEMP. This subroutine controls the surface temperature secant iteration scheme. E3, the difference between the assumed surface temperature and the calculated surface temperature based on the surface energy balance, is forced to converge to zero.

SOXCAL. This subroutine computes the burning surface geometry for a given oxidizer particle size pseudo-propellant. The propellant surface is assumed to be composed of equal numbers of positive and negative protruding or recessed oxidizer particles (positive and negative referring to the hemisphere of the oxidizer particle associated with the mean state). The fuel binder surface temperature, TSB, is iteratively computed if the separate surface temperature approach is assumed (ITS2=1) via satisfaction of continuity for both oxidizer and fuel mass flows. Surface roughness for the pseudo-propellant, RUFF(55), is calculated based on the observed surface geometry. Finally, a slipline correction factor, AFAC, is calculated if the equal mass fluxes assumption (ISLIP=1) is envoked by the user.

SEB. This subroutine solves the energy balance at the propellant surface. The major portion of this subroutine is used to control the calculation of the individual flame standoff distances. Also, the nondimensional flame standoff distances and the flame heat release parameters are determined. With this information, based on an assumed value of surface temperature, the energy transmitted to the propellant surface from the various flames is computed and compared to the quantity of energy required to raise the propellant from it's initial solid propellant temperature to the assumed surface temperature corrected for any exothermic or endothermic surface reactions. If equality is obtained, the proper

pseudo-propellant surface temperature is obtained. The following variables are calculated within this subroutine:

XSTPF	the primary flame kinetic flame standoff distance.
XSTAP	the oxidizer monopropellant flame kinetic flame standoff distance.
XSTPD	the primary flame diffusion flame standoff distance.
XSTFD	the final flame diffusion flame standoff distance.
QAP	the oxidizer monopropellant flame heat release.
QPF	the primary flame heat release.
QFF	the final flame heat release.
TSAP	the percent contribution of the surface energy flux due to the oxidizer monopropellant flame.
TSPF	the percent contribution of the surface energy flux due to the primary flame.
TSFF	the percent contribution of the surface energy flux due to the final flame.
TSAL	the percent contribution of the surface energy flux due to the combustion associated with aluminum particles.

QALUM. This subroutine controls the portion of the steady state combustion model concerned with calculating the quantity of energy released during the combustion of aluminum particles that is transferred back to the propellant surface. This portion of the computer model is entered only if aluminum is present in the propellant formulation (BETA not equal to zero). The following six subroutines are concerned with the aluminum modeling mechanisms within the theoretical PEM.

SURFAL. This subroutine determines the state of the aluminum particle, that is, its temperature, TALS, as it emerges from the propellant

surface. The aluminum particle is assumed to heat up as it emerges from the surface. After emerging from the propellant, it flows away due to viscous drag forces again heating up due to its presence in the hot gas stream. If the temperature of the aluminum particle reaches the the aluminum oxide melting temperature, TSMELT, ignition occurs. The following variables are used during the aluminum combustion analysis and are described below for future reference, especially in discussing the sample case for an aluminized propellant.

DAGGL	the diameter of the liquid aluminum particle.
VG	the velocity of the hot gas stream issuing from the propellant surface.
TIGN	time till ignition as referenced from the time of completed surface emergence of the aluminum particle.
XIGN	distance above the propellant surface of the center of aluminum particle at the instant of ignition.
DLOFF	the diameter of the aluminum particle at lift off from the propellant surface.
VELP	the velocity of the aluminum particle at the instant of ignition.
TCOMB	the time for completed combustion of the aluminum particle.
XCOMB	the distance above the propellant surface attained by the center of the aluminum particle at the moment of of completed combustion.

EMERG. This subroutine performs the required incremental aluminum particle propellant surface emergence analysis. The primary function of

this subroutine is to calculate and keep track of the heat transfer to the aluminum particle from either the hot gas or the solid propellant during the emergence process. This information is necessary in order to establish the aluminum particle temperature/time relationship during this crucial point in the aluminum lifetime.

ALCOMB. This subroutine calculates the total heat transfer from the burning aluminum particle to the propellant surface as the aluminum particle accelerates away from the surface. A fourth order Runge-Kutta scheme is used in the integration of the heat release transferred to the propellant surface over the path traveled by the burning aluminum particle away from the propellant surface.

DVPDT. This subroutine calculates the instantaneous acceleration of the aluminum particle as a function of time and velocity.

CD. This subroutine calculates the coefficient of drag for a sphere as a function of the Reynolds number based on the aluminum particle diameter, the relative gas velocity and the gas phase properties.

ENHANC. This subroutine calculates the thermal conductivity enhancement factor at a specified distance above the propellant surface, YST. This value is calculated from the local value of eddy viscosity, EDY(461). If a crossflow velocity is not present and a turbulent boundary layer has not been calculated (IEDY=0) then a value of unity is returned.

TRANS. This subroutine is used to calculate the values of the transport properties of thermal conductivity and mass diffusivity as a function of flame zone average temperature, combustion pressure, and amount of boundary layer turbulence present. INDEX is a control parameter having the following effects:

If INDEX equals 0, the flame zone thermal conductivities are calculated.

If INDEX equals 1, the final flame zone diffusivity is calculated.

If INDEX equals 2, the primary flame zone diffusivity is calculated.

If INDEX equals 3, the boundary layer gas properties are calculated.

If INDEX equals 4, the gas stream properties are calculated for the aluminum modeling analysis.

The following parameters are calculated within this subroutine.

XLAMPF(55)	an array of the pseudo-propellant primary flame zone thermal conductivities.
XLAMAP(55)	an array of the pseudo-propellant oxidizer monopropellant flame zone thermal conductivities.
XLAMFF(55)	an array of the pseudo-propellant final flame zone thermal conductivities.
GAMAPF(55)	an array of the pseudo-propellant primary flame zone mass diffusivities.
GAMAFF(55)	an array of the pseudo-propellant final flame zone mass diffusivities.

RESIST. This subroutine computes the average value of resistivity for an arbitrary distance above the propellant surface. If a crossflow velocity is not present and a turbulent boundary layer has not been calculated (IEDY=0) then a value of unity is returned.

AFHC. This subroutine calculates the average flame standoff distance parameter, AFH, for each of the diffusion flames. The expressions thus derived are appropriate only for parabolic conical flames.

ETA. This subroutine controls the calculational flow for determining the nondimensional diffusion flame standoff distance, ETA. INDEX

is a control parameter; if INDEX equals 1, the final diffusion flame is calculated and if INDEX equals 2, the primary diffusion flame is calculated.

<u>BURKES</u>. This subroutine performs the Burke-Schumann series solution in order to determine the diffusion flame standoff distances for either the final diffusion flame (INDEX=1) or the primary diffusion flame (INDEX=2). A Newton iteration numerical scheme is employed in order to converge upon a solution. In either the final flame or the primary flame calculations, a test is performed to determine whether the flame closes over the oxidizer surface or over the fuel binder surface. During erosive burning calculations, an iteration on the Burke-Schumann diffusivity related parameter, ZSI, must be performed due to the enhancement of the mass diffusivity coefficient.

<u>DISTF</u>. This subroutine calculates the oxidizer distribution function from known oxidizer particle size distribution data.

<u>LSQFIT</u>. This subroutine takes calculated burning rate versus combustion pressure data and performs a linear least square fit in order to determine the St. Robert's law proportionality constant, C, and the pressure exponent, XN. A goodness of fit correlation coefficient, RSQ, is also returned.

<u>INTEG</u>. This subroutine performs a Simpson's integration over all the oxidizer particle diameters for mode number, M, of the argument array, ARG(541). The primary purpose of this subroutine is in the calculation of the overall burning rate or response function of a propellant based upon the calculated pseudo-propellant burning rates or response functions. INDEX is a control parameter; if INDEX equals 0, the integration is performed over NDPM oxidizer diameters and if INDEX equals 1, the integration is performed over NXDPM oxidizer diameters.

BROOT. This subroutine provides the value of the Jth zero of the Bessel function of the first kind of order one, J_1.

BESSEL. This subroutine calculates the Bessel functions of the first kind of order zero and one that are used in the Burke-Schumann diffusion flame series solution.

CCAL. This subroutine computes the constant of proportionality, CX, in the expression for the volume of fuel binder associated with an oxidizer particle of a given diameter. A Simpson's integration analysis is performed with the answer being related to the assumed diameter exponent, XN, and the oxidizer distribution function, XFSKP(541).

QUAD. This is a utility subroutine that fits a second order curve through three pairs of variables.

CUBIC. This is a utility subroutine that fits a third order curve through four pairs of variables.

PRESIN. This subroutine is called by LINKOO in order to increment the combustion pressure. Within a burning rate versus combustion pressure calculation, this subroutine calculates NPRESS pressures logarithmically spaced between PSTART and PSTOP.

OXDATA. This subroutine contains data corresponding to the thirty-three propellant formulations supplied by the RPL for investigation. This subroutine is called in INPUT if NPROP, the propellant number, is nonzero. For every propellant formulation, the oxidizer particle size distribution data is supplied, the fuel binder type is designated and all other parameters related to various propellant formulation additives are provided. Adiabatic flame temperature and molecular weight data required by subroutine FLAMET are also provided for each propellant formulation.

C. OVERLAY (PEM1,1,0)

LINK10. This program routine is the main control routine in OVERLAY (PEM1,1,0). Its primary function is calling subroutine EROSIV.

EROSIV. This subroutine controls the flow of the erosive burning calculations. The principal function of this subroutine is to iterate on an erosive burning rate that is consistent with the enhanced values of the transport properties due to the presence of a turbulent boundary layer above the burning propellant surface. The many control parameters read in through the EROSDT namelist aid in the rapid convergence upon the erosive burning rate for a given propellant formulation subjected to a prescribed crossflow environment. Aside from a control nature, this subroutine stores much of the intermediate results for future output, directs much of the output, and calls HAMRV and DERRV if velocity coupled response is to be calculated.

HAMRV. This subroutine directs the program flow for the nonsteady state velocity coupled response using the small perturbation method. The nonsteady state velocity coupled response is not calculated in this subroutine; this function is performed in the routine LINK20. However, the perturbation of the steady state erosive burning model equations is performed whenever the control parameter, IRVHM, equals one. For each pseudo-propellant, the crossflow velocity and the surface temperature is perturbed systematically within the framework of the steady state erosive burning rate calculations and the various g parameters, referred to in the theoretical analysis portion of the final report of this contract under separate cover, can be calculated and stored for future use in LINK20. From the values of the g parameters thus calculated, four parameter

arrays, C(55,1), C(55,2), C(55,3) and C(55,4), can be generated. Also, the zero frequency limit of the velocity coupled response function, the crossflow velocity exponent array, PXNE(55), can be filled.

DERRV. This subroutine directs the program flow for the nonsteady state velocity coupled response using either the method of Lengelle or the Zeldovich/Novozhilov method. The nonsteady state velocity coupled response is not calculated in this subroutine; this function is performed in the routine LINK20. However, the steady state h parameters, referred to in the theoretical analysis portion of the final report of this contract under separate cover, are calculated via a systematic perturbation of the crossflow velocity and the initial solid propellant temperature. The following steady state combustion parameter arrays thus calculated are as follows. The corresponding h parameter designation is also given where applicable.

PXNE(55)	an array of pseudo-propellant crossflow velocity exponents (h_1).
PXM(55)	an array of values related to the pseudo-propellant's sensitivity of surface temperature to changes in the crossflow velocity (h_3).
PXK(55)	an array of values related to the pseudo-propellant's sensitivity of erosive burning rate to changes in initial solid propellant temperature (h_2).
PXS(55)	an array of pseudo-propellant erosive burning temperature sensitivities.
PXR(55)	an array of values related to the pseudo-propellant's sensitivity of surface temperature to changes in the initial solid propellant temperature (h_4).

PXD(55)	an array of pseudo-propellant properties $(h_1h_4-h_2h_3)$.
ES1(55)	an array of pseudo-propellant effective surface activation energies via the crossflow velocity perturbation scheme.
ES2(55)	an array of pseudo-propellant effective surface activation energies via the initial solid propellant temperature perturbation scheme.

EDYCAL. This subroutine calculates the turbulent boundary layer velocity profile and the subsequent average resistivity profile as a function of the surface normal coordinate, Y. A fourth order Runge-Kutta scheme is employed in solving the governing first order differential boundary layer equation in the variable, DUDY. The following variables are used within this analysis:

REINF	the Reynolds number based on the crossflow velocity, the hydraulic diameter, DIAH, and the boundary layer gas properties of density, RHOBL, and viscosity, XMEWBL.
CFZERO	the value of the coefficient of friction at the propellant surface without surface blowing.
CF	the value of the coefficient of friction at the propellant surface with surface blowing.
AMINJ	the surface mass blowing strength.
TAUW	the shear stress at the propellant surface with surface blowing.
TAUWZ	the shear stress at the propellant surface without surface blowing.
BLOW	the surface blowing parameter.

SURFAV. This subroutine calculates the surface average value of an array so specified. IBIN is a control parameter; if IBIN equals 0, the average is based upon the oxidizer surface and if IBIN equals 1, the average is based upon the fuel binder surface.

SLOPE. This subroutine calculates the derivative of the variable, DUDY, as a function of the surface normal coordinate, YPOS. This is used in the fourth order Runge-Kutta scheme performed in EDYCAL.

YGRID. This subroutine sets up the grid spacing in the surface normal coordinate for the numerical velocity profile calculation performed in EDYCAL.

COEF. This subroutine determines the value of the coefficient of skin friction for channel flow with zero surface blowing. The effect of surface roughness, RUFFAV, is taken into account.

CFCFZ. This subroutine calculates the reduction in skin friction which occurs due to the presence of surface blowing. Any one of four different expressions can be envoked via the IBLOW control parameter.

LIST. This subroutine is a general purpose subroutine which lists the numerical values of a given array, VAR(N).

D. OVERLAY (PEM2,2,0)

LINK20. This program routine is the main control routine in OVERLAY (PEM2,2,0). Its primary function is calling subroutine NSINTG.

NSINTG. This subroutine controls the flow of the nonsteady state response calculations. Depending on the control parameters entered via the RESPDT namelist, either the pressure coupled response or the velocity coupled response can be calculated for each pseudo-propellant. Four

pressure coupled response models can be selected; the small perturbation technique (IRPHM=1), the Zeldovich/Novozhilov method (IRPZN=1), the Denison and Baum/Cohen technique (IRPDB=1), and the original Denison and Baum technique (IRPDB=2). Likewise, four velocity coupled response models can be selected; the small perturbation technique (IRVHM=1), the Zeldovich/Novozhilov method (IRVZN=1), the Lengelle technique based on the Denison and Baum/Cohen pressure coupled model (IRVDB=1), and the Lengelle technique based on the original Denison and Baum pressure coupled model (IRVDB=2). After each pseudo-propellant response has been calculated for a given value of frequency, the overall propellant response function can be determined via an integration over all oxidizer particle diameters within the propellant formulation. Either a series summation scheme (IKING=0) or a parallel summation scheme (IKING=1) can be employed. In this manner the overall propellant response function is determined for NOMEG values of frequency between OSTART and OSTOP. During this procedure, the overall propellant response versus frequency data is read onto a tape for future storage and/or plotting.

RESPON. This subroutine calculates the pseudo-propellant response as required by NSINTG for the data determined in HAMRP and DERRP for the pressure coupled response and HAMRV and DERRV for the velocity coupled response.

QINTER. This is a utility subroutine that performs a quadratic interpolation of an arbitrary variable at a given oxidizer diameter when the value of the variable is known only at discrete oxidizer diameters. This routine is used in the nonsteady state integration schemes.

PHASE. This is a utility subroutine that calculates the phase angle and magnitude of a complex variable, ZETA. The real part of the

complex number, XR, the imaginary part of the complex number, XI, the magnitude, XMAG, and the phase angle in degress, PHI, are all returned to the calling routine.

ABCAL. This subroutine controls the calculation of the Denison and Baum A and B parameter based upon the Cohen postulates relating the peak pressure coupled response, RPP, and the frequency of the peak, FREQP, to pseudo-propellant properties.

ABCONV. This subroutine performs a secant iteration on the Denison and Baum A parameter for a particular pseudo-propellant. The converged value of A with its corresponding B parameter returned to ABCAL are consistent with the Cohen postulates.

AFIND. This subroutine computes the minimum and maximum values of the Denison and Baum A parameter for a particular pseudo-propellant. These values are used in the iteration scheme in ABCONV.

BCAL. This subroutine calculates a value of the Denison and Baum B parameter for a given A value.

DIFCAL. This subroutine calculates the derivative of the Denison and Baum response with respect to the nondimensional frequency. This information is also used in the secant iteration scheme employed by ABCONV.

E. OVERLAY (PEM3,3,0)

LINK30. This program routine is the main control routine in OVERLAY (PEM3,3,0). Its primary function is calling subroutine BPLOT.

BPLOT. This subroutine, a general purpose plotting routine, controls the plotting of the nonsteady state pressure coupled or velocity coupled response versus frequency data generated by the computer program. The

plotting control parameters are entered via formatted read statements within this subroutine. The data to be plotted is read in via binary tape read statements or formatted read statements in subroutine DATPLT. The type of plots generated are box style with the lower x axis being annotated while either of the two y axes being annotated. Both linear and logarithmic axes can be generated. This plotting routine is heavily commented throughout the program listing so therefore, little description will be given here. This plotting routine contains many of the standard CALCOMP calls and should be compatible on most computer systems. However, the user maintains the option to substitute his own plotting routine if so desired.

AXISRG. This subroutine controls the generation of a linear axis. Any one of three axes can be annotated in this fashion; the bottom x axis and either of the two y axes.

LOGAX. This subroutine controls the generation of a logarithmic axis. Any one of three axes can be annotated in this fashion; the bottom x axis and either of the two y axes.

CFIT. This is a general purpose curve fitting routine used in conjunction with the plotting routine. In order to generate smooth response curves from the calculated discrete response function/frequency data points, curve fits are assigned between points with additional data to be plotted being generated. As before, this routine is highly commented within the program listing and little more will be thus added.

OUTP. This subroutine is a general purpose subroutine which lists the response function versus frequency data being plotted. The results of the curve fitting subroutine, CFIT, are also incorporated within this data listing.

DATPLT. This subroutine controls the plotting once the plot format has been generated. The data to be plotted is either read in through formatted read statements or via binary tape reading. If curve fitting of the data is to be carried out, this routine directs the flow of the program to CFIT. IFLAG is a control parameter described in BPLOT which directs the plotting.

IV. INPUT PARAMETERS

A. INTRODUCTION

In this section, each input parameter is defined. The input data required for execution of the computer program are entered by both namelist input and formatted read statements. In all cases, the seven namelists, FLAG, PARMST, PROPDT, ALUMDT, EROSDT, RESPDT, and OXDIST, are entered. In general, only those parameters and data pertinent to the particular problem being considered must be entered. Many input parameters have default values and do not need to be specified unless values other than the default values are to be entered. Where applicable, the default value of the individual input parameters is given in parentheses.

B. NAMELIST FLAG

The parameters entered in namelist FLAG control some of the aspects pertaining to the steady state modeling.

IBDP — If IBDP equals 1, each oxidizer particle size distribution is treated as being monodisperse (0).

IKING — If IKING equals 0, burning rate is calculated with a series summation technique. If IKING equals 1, burning rate is calculated with a parallel summation technique. If IKING is

not equal to either 0 or 1, other combination summation techniques are employed (0).

IPRNT1 If IPRNT1 equals 1, the namelist groupings are printed (0).

IPRNT2 If IPRNT2 equals 1, an expanded surface energy iteration output is produced (0).

ISLIP If ISLIP equals 1, a diffusion flame slipline is assumed. The fuel and oxidizer surface mass fluxes are constrained to be equal (1).

ITFAD If ITFAD equals 1, adiabatic flame temperatures and molecular weights are inputed at three pressures for the propellant formulation under consideration (0).

ITS2 If ITS2 equals 1, a two surface temperature analysis is performed (0).

NSOX If NSOX equals 1, the oxidizer surface geometry can be inputed, bypassing the calculations performed in subroutine SOXCAL (0).

C. NAMELIST PARMST

Parameters pertaining to the numerical analyses within the combustion model are inputed through the namelist PARMST. Also, external environmental conditions such as the pressure and initial solid propellant temperature are specified through this namelist grouping.

ERRBES Minimum magnitude of the last term considered in the Burke-Schumann diffusion flame series solution (.0000001).

ESTART Initial guess for the value of the nondimensional diffusion distance in the Burke-Schumann diffusion flame series solution (.1).

ETALIM Convergence limit on the nondimensional diffusion distance in the Burke-Schumann diffusion flame series solution (.00001).

ITLIM2 Iteration limit on the nondimensional diffusion distance in the Burke-Schumann diffusion flame series solution (20).

ITLIM3 Surface temperature iteration limit (20).

LIMBES Maximum number of terms taken in the Burke-Schumann diffusion flame series solution (40).

NARRAY(5) An array specifying the number of pseudo-propellant diameters per mode, where the index is the total number of modes considered, MODES (21,15,15,13,11).

NXDFAC Number of diameter increments between consecutive pseudo-propellant diameters used in nonsteady state response calculations (10).

NPRESS Number of pressures that are to be considered in a rate versus pressure calculation (1).

PSTART Starting pressure for rate versus pressure calculations or the assigned pressure for the erosive burning or nonsteady state response calculations (68.0272 atm.).

PSTOP Stopping pressure for rate versus pressure calculations or the assigned pressure for the erosive burning or nonsteady state response calculations (68.0272 atm.).

SOXP The ratio of the total oxdizer surface area to the planar oxidizer surface area so specified when NSOX = 1 (1.0).

TSLIM Convergence limit on the surface temperature in the surface temperature iteration scheme (.01 K).

TSMAX Maximum surface temperature allowed in the surface temperature iteration scheme (2500 K).

TSMIN	Minimum surface temperature allowed in the surface temperature iteration scheme (750 K).
TSST	Starting surface temperature in the surface temperature iteration scheme (950 K).
TZERO	Initial solid propellant temperature (294.15 K).
XN	Oxidizer particle diameter exponent utilized in the expression for the volume of fuel associated with an oxidizer particle of a given diameter (3.0).
XNUHI	Maximum value for the oxidizer volume fraction for which the Burke-Schumann diffusion flame series solution is rigorously executed (approximation used for larger values) (.98).
XNULOW	Minimum value for the oxidizer volume fraction for which the Burke-Schumann diffusion flame series solution is rigorously executed (approximation used for smaller values) (.3).

D. NAMELIST PROPDT

Parameters pertaining to the actual propellant under consideration are inputed through this namelist. That is, the various oxidizer, fuel and non-aluminum solid phase and gas phase properties are specified by this namelist grouping.

AAP	Pre-exponential frequency factor for the oxidizer mono-propellant flame reaction kinetics ($2.5X10^6$ cm^3-g/s-atm^a).
AF	Pre-exponential frequency factor for the fuel binder surface decomposition reaction-HTPB (299 g/cm^2-s).
ALFADD(2)	An array specifying the mass fractions of a possible two non-aluminum and non-catalyst additives (0,0).

ALFCAT	Mass fraction of catalyst (0.0).
AMW1 AMW2 AMW3	Molecular weights of final combustion products at three values of pressure: 34.0136, 68.0272, and 136.0544 atmospheres, respectively. These values are calculated via the NASA Thermochemistry Program based on the propellant formulation considered. Default values are for an 88 percent AP/12 percent HTPB propellant (25.881, 25.987, 26.083 g/gmole).
AOX	Pre-exponential frequency factor for the oxidizer decomposition reaction-AP (16600 g/cm^2-s).
APF	Pre-exponential frequency factor for the primary flame reaction kinetics (1400 cm^3-g/s-atm^b).
APW1 APW2 APW3	Molecular weights of the oxidizer decomposition flame combustion products at three values of pressure: 34.0136, 68.0272, and 136.0544 atmospheres, respectively. These values are calculated via the NASA Thermochemistry Program for AP (27.859, 27.917, 27.982 g/gmole).
CAP	Constant in the exponential expression for the oxidizer monopropellant flame activation energy in the presence of a catalyst (0.0).
CIGN	Proportionality factor in the oxidizer ignition delay expression (190 s-atm^m/cm^n).
CP	Specific heat of the gas phase (.4 cal/g-K).
CPF	Constant in the exponential expression for the primary flame activation energy in the presence of a catalyst (14.96).
CS	Specific heat of the solid phase (.2 cal/g-K).
DELAP	Oxidizer monopropellant flame reaction order-a (1.0).

DELPF Primary flame reaction order-b (1.5).

EAP Activation energy for the oxidizer monopropellant flame reaction kinetics (25000 cal/gmole).

EAP2 Limiting value of the oxidizer monopropellant flame activation energy in the presence of a catalyst (0 cal/gmole).

EF Activation energy for the fuel binder surface decomposition reaction-HTPB (16900 cal/gmole).

EOX Activation energy for the oxidizer decomposition reaction-AP (21000 cal/gmole).

EPF Activation energy for the primary flame reaction kinetics (15000 cal/gmole).

EPF2 Limiting value of the primary flame activation energy in the presence of a catalyst (2610 cal/gmole).

FACTOR Ratio of the change in flame temperature to a change in the initial solid propellant temperature (1.0).

GAMMA Constant of proportionality for the expression which relates the mass diffusion coefficient for the combustion gases to the mass diffusion coefficient at STP (.0000076 cm^2-atm/$K^{1.75}$-s).

IADD Number of non-aluminum, non-catalyst additives considered (0).

IADTYP(2) Array specifying the additive type: 0 - no additive, 1 - Zirconium carbide (ZrC), 2 - Graphite (0,0).

ICAT Value specifying the catalyst type: 0 - no catalyst, 1 - Fe_2F_3, 2 - Fe_2O_3, 3 - CuPh, 4 - Ferrocene (0).

IFUEL Value specifying the fuel binder type: 1 - HTPB, 2 - PBAN (1).

PLAMB Thermal conductivity of solid phase of propellant (.0003 cal/cm-s-K).

POWD	Oxidizer particle diameter exponent in the oxidizer ignition delay expression-n (.80).
POWIG	Pressure exponent in the oxidizer ignition delay expression-m (.721).
QFUEL	Heat of pyrolysis of fuel binder-HTPB (433 cal/g).
QL	Oxidizer latent heat of decomposition-AP (0.0 cal/g).
RHOF	Density of fuel binder-HTPB (.92 g/cm^3).
RHOX	Density of oxidizer-AP (1.95 g/cm^3).
SPSUR	Specific surface of catalyst (0.0 cm^2/g).
TF1 TF2 TF3	Adiabatic flame temperature of final combustion products at three values of pressure: 34.0136, 68.0272, and 136.0544 atmospheres, respectively. These values are calculated via the NASA Thermochemistry Program based on the propellant formulation considered. Default values are for an 88 percent AP/12 percent HTPB propellant (2969.4, 3013.7, 3053.6 K).
XLAMB	Constant of proportionality for the expression which relates the thermal conductivity for the combustion gases to the thermal conductivity at STP (.00005 cal/cm-s-K$^{1.5}$).
XNUFF	Final flame stoichiometry variable used in the Burke-Schumann diffusion flame analysis-AP/HTPB (9.3).
XNUPF	Primary flame stoichiometry variable used in the Burke-Schumann diffusion flame analysis-AP/HTPB (9.3).

E. NAMELIST ALUMDT

Parameters related to the aluminum particle combustion modeling within the PEM are inputed through this namelist.

BETA	Mass fraction of metal within the propellant formulation (0.0).
BETAC	Aluminum particle burning rate power law constant (.004 cm^2/s).
CPM	Aluminum solid and liquid phase specific heat (.214 cal/g-K).
DBARM	Fifty percent weight mean diameter of aluminum particle size ditribution within propellant (6 microns).
DELC	Aluminum particle diameter exponent in power law burning expression (2.0).
DELHR	Aluminum heat of combustion (1800 cal/g).
G	Gravitational constant (980 cm/s^2).
GSUR	Imposed acceleration field (+ into propellant) (0.0 cm/s^2).
IALUM	Value specifying aluminum type: 0 - no aluminum, 1 - Al, 2 - Al_2O_3 (0).
IMET	Number of steps in aluminum combustion integration (30).
IALST	Number of steps in aluminum surface emergence integration (100).
IPRNT4	If IPRNT4 equals 1, an expanded aluminum interation output is produced (0).
ISINK	Value specifying aluminum model to employ: 0 - full aluminum emergence/ignition/combustion model, 1 - simplified heat sink model (0).
QM	Latent heat of liquifaction of aluminum (96 cal/g).
RHOL	Density of liquid aluminum (2.35 g/cm^3).
RHOM	Density of solid aluminum (2.71 g/cm^3).
SIGMAM	Mode width parameter of aluminum particle size distribution (1.0).

TMELT	Melting point temperature of solid aluminum (933 K).
TSMELT	Melting point temperature of Al_2O_3 (2320 K).

F. NAMELIST EROSDT

Parameters related to the erosive burning modeling within the PEM are inputed through this namelist.

CONC	Proportionality constant in the relation between the molecular and turbulent thermal condustivities and the molecular and turbulent viscosities (1.0).
COND	Proportionality constant in the relation between the molecular and turbulent mass diffusion coefficients and the molecular and turbulent viscosities (1.0).
CPRIME	Proportionality constant in the Prandtl mixing length equation used in the turbulent boundary layer analysis (.16).
DIAH	The hydraulic diameter of the flow channel above the burning propellant surface (2.0 cm).
DYIN	Initial increment in the surface normal direction in the numerical velocity profile calculational grid (.000001 cm).
EBRLIM	Convergence limit on the erosive burning rate (.0001 cm/s).
ERATE(10)	Array of erosive burning rates or surface blowing rates used to expedite erosive burning convergence (10*1.0 cm/s).
IBLOW	Parameter designating the appropriate expression for the reduction in the skin friction coefficient under the influence of surface blowing (4).
IEFLAG	Erosive burning control parameter: If IEFLAG is negative, investigate ABS(IEFLAG) rates from the array ERATE (10) with velocity profiles listed for each rate; if IEFLAG is equal to zero, perform normal iteration on the erosive

burning rate; if IEFLAG is positive, investigate IEFLAG rates from the array ERATE(10) without velocity profiles being listed (0).

IEPRT1	Erosive burning control parameter: If IEPRT1 equals 0, no velocity profiles are listed; if IEPRT1 equals 1, only the final iterations velocity profile is listed; if IEPRT1 equals 2, velocity profiles for all iterations are listed.
IEPRT2	If IEPRT2 is equal to 1, an expanded erosive burning output is provided (0).
IERATE	If IERATE is equal to 1, the normal erosive burning iteration is performed with the first rate being equal to ERATE(1) (0).
INSTEP	Number of increments in the surface normal direction per logarithmic cycle in the numerical velocity profile calculational grid (100).
IPRNT3	If IPRNT3 equals 1, print the velocity profile numerical scheme (0).
IROUGH	If IROUGH equals 1, surface roughness is taken into account in the calculation of the skin friction coefficient (1).
ITERO	Maximum number of iterations allowed in the erosive burning rate numerical solution (20).
ITLIM1	Iteration limit on the nondimensional diffusion coefficient of the Burke-Schumann diffusion flame series solution under the influence of erosive burning (10).
NCYC	Number of logarithmic cycles in the surface normal direction used in the numerical erosive burning calculational grid (5).

UINF Value of the free stream crossflow velocity used in the erosive burning calculations (0.0 cm/s).

XMEW Constant of proportionality for the expression which relates the molecular viscosity for the combustion gases to the molecular viscosity at STP (.00002 g/cm-s-$K^{.5}$).

YSTART Starting value of the surface normal coordinate used in the numerical erosive burning calculational grid (0.0 cm).

ZSILIM Convergence limit on the nondimensional diffusion coefficient of the Burke-Schumann diffusion flame series solution under the influence of erosive burning (.00001).

G. NAMELIST RESPDT

Parameters related to the nonsteady state response modeling within the PEM are inputed through this namelist.

BFAC Proportionality constant for the Cohen postulate for the magnitude of the Denison and Baum pressure coupled response at the peak frequency (1360 microns).

FFAC Proportionality constant for the Cohen postulate of the peak frequency of the Denison and Baum pressure coupled response (4.72).

IPHMG If IPHMG equals 1, phase and magnitude information is listed for the pressure and velocity coupled response functions (1).

IRPDB If IRPDB equals 1, calculate the pressure coupled response function with the Denison and Baum/Cohen technique. If IRPDB equals 2, calculate the pressure coupled response function with the original Denison and Baum technique (0).

IRPHM If IRPHM equals 1, calculate the pressure coupled response function with the small perturbation technique (0).

IRPZN If IRPZN equals 1, calculate the pressure coupled response function with the Zeldovich/Novozhilov technique (0).

IRVDB If IRVDB equals 1, calculate the velocity coupled response function based on the analysis of Lengelle with the pressure coupled response calculated with the Denison and Baum/Cohen technique. If IRVDB equals 2, calculate the velocity coupled response function in the same manner, however, the pressure coupled response is calculated with the original Denison and Baum technique (0).

IRVHM If IRVHM equals 1, calculate the velocity coupled response function with the small perturbation technique applied to the erosive burning model (0).

IRVZN If IRVZN equals 1, calculate the velocity coupled response function with the Zeldovich/Novozhilov technique applied to the erosive burning model (0).

NOMEG Number of frequencies for which the nonsteady state response functions are calculated (81).

NPLOT Number of tape containing response function versus frequency data to be plotted. If NPLOT equals 0, no plotting is performed (0).

NSFLAG If NSFLAG equals 1, expanded nonsteady state analysis output is generated (0).

OSTART First frequency for which the nonsteady state response function is calculated (10 cycles/s).

OSTOP Last frequency for which the nonsteady state response function is calculated (100000 cycles/s).

PPER | Pressure perturbation parameter used in the pressure coupled small perturbation technique (.005).

PPERD | Pressure perturbation parameter used in the pressure coupled Zeldovich/Novozhilov technique (.005).

TPERD | Initial solid propellant temperature perturbation parameter used in the pressure coupled Zeldovich/Novozhilov technique (.005).

TSPER | Surface temperature perturbation parameter used in the pressure and velocity coupled small perturbation techniques (.005).

UPER | Crossflow velocity perturbation parameter used in the velocity coupled small perturbation technique (.005).

UPERD | Crossflow velocity perturbation parameter used in the velocity coupled Zeldovich/Novozhilov technique (.005).

H. NAMELIST OXDIST

Parameters describing the oxidizer particle size distribution of the propellant are inputed through this namelist.

ALFAI(5) | Array representing the mass fraction for each of the oxidizer modes (.88,0.0,0.0,0.0,0.0).

DBARI(5) | Array representing the fifty percent weight mean diameter for each of the oxidizer modes (80.,0.0,0.0,0.0, 0.0,0.0 microns).

MODES | Parameter specifying the number of oxidizer modes (1).

NEXTC | Control parameter. If NEXTC equals 0, the program will stop after executing case depicted by the previous namelists. If NEXTC equals 1, seven new namelists are called after execution in order to run an additional case (0).

NPROP Parameter representing a particular propellant number for which oxidizer particle size distribution data as well as fuel and additive information are availalbe with a call to subroutine OXDATA (0).

SIGMAI(5) Array representing the mode width parameter for each of the oxidizer modes (2.0,0.0,0.0,0.0,0.0).

I. PLOTTING ROUTINE INPUT

The input to the plotting routine is the only formatted read input used in the PEM computer program. Below is a list of the various read statements, the format required, and a brief description of the parameters involved. As stated previously, since the plotting routine is highly commented throughout its listing, only brief descriptions of the many parameters are given in this section. The user is referred to the program listing of the plotting routine available upon request from AFRPL for further information.

CARD 1 READ; XSIZE, YSIZE, NANNOT, NFLUSH

FORMAT (2F10.0,2I5)

XSIZE	size of the x axis in millimeters.
YSIZE	size of the y axis in millimeters.
NANNOT	y axis annotation control parameter.
NFLUSH	axis labeling centering control parameter.

CARD 2 READ; XMIN, XMAX, NXDIV, NXTYPE, NFX, XFORM

FORMAT (2F10.0,3I5,A10)

XMIN	minimum x axis value.
XMAX	maximum x axis value.
NXDIV	number of x axis divisions.
NXTYPE	x axis type control parameter.

NFX	x axis numbering format length,
XFORM	x axis numbering format.

<u>CARD 3</u> READ; XHGHTN, XHGHT, NXS, XSTRNG

FORMAT (2F5.0,I10,6A10)

XHGHTN	x axis number height in millimeters
XHGHT	x axis labeling height in millimeters
NXS	number of characters in axis annotation.
XSTRNG	x axis annotation.

<u>CARD 4</u> READ; YMIN, YMAX, NYDIV, NYTYPE, NFY, YFORM

FORMAT (2F10.0,3I5,A10)

YMIN	minimum left y axis value.
YMAX	maximum left y axis value.
NYDIV	number of left y axis divisions.
NYTYPE	left y axis type control parameter.
NFY	left y axis numbering format length.
YFORM	left y axis numbering format.

<u>CARD 5</u> READ; YHGHTN, YHGHT, NYS, YSTRNG

FORMAT (2F5.0,I10,6A10)

YHGHTN	left y axis number height in millimeters.
YHGHT	left y axis labeling height in millimeters.
NYS	number of characters in left y axis annotation.
YSTRNG	left y axis annotation.

<u>CARD 6</u> READ; YMINR, YMAXR, NYDIVR, NYTYPR, NFYR, YFORMR

FORMAT (2F10.0,3I5,A10)

YMINR	minimum right y axis value.
YMAXR	maximum right y axis value.
NYDIVR	number of right y axis divisions.

NYTYPR right y axis numbering format length.

YFORMR right y axis numbering format.

CARD 7 READ; YHGTNR,YHGHTR, NYSR, YSTNGR

FORMAT (2F5.0,I10,6A10)

YHGTNR right y axis number height in millimeters.

YHGHTR right y axis labeling height in millimeters.

NYSR number of characters in right y axis annotation.

YSTNGR right y axis annotation.

CARD 8 READ; XORIG, YORIG

FORMAT (2F10.0)

XORIG reference x origin in millimeters.

YORIG reference y origin in millimeters.

CARD 9 READ; NLABEL

FORMAT (I2)

NLABEL number of label strings to be plotted.

CARD 10 READ; XPOS, YPOS, HLBL, ANGLE, NCHAR, LABEL

FORMAT (4F4.0,I4,6A10)

XPOS starting x value for label string.

YPOS starting y value for label string.

HLBL label character height in millimeters.

ANGLE label angle in degrees.

NCHAR number of characters in label string.

LABEL label string.

(note ... there should be NLABEL of the above card)

CARD 11 READ; IFLAG

FORMAT (I5)

IFLAG plotting control parameter.

CARD 12 READ; NY, NJ, NONCEN, ICURVF, NPLT, NDIV, ITAPE

FORMAT (7I5)

NY	right or left y axis control parameter.
NJ	pen control parameter.
NONCEN	on-center symbol control parameter.
ICURVF	curve fitting routine control parameter.
NPLT	number of data points to plot.
NDIV	number of points to generate in curve fitting routine between consecutive data points.
ITAPE	number of tape off which to read data to be plotted.

CARD 13 READ; XPLOT(I), YPLOT(I)

FORMAT (2F10.0)

XPLOT	x value of x-y data point.
YPLOT	y value of x-y data point.

(note ... there should be NPLT of the above card)

V. OUTPUT INTERPRETATION

The first page of output generated by the computer program consists of a listing of the various input parameters read in through the namelist input groupings. This includes the oxidizer size distribution information, along with the many oxidizer, fuel binder, aluminum and non-aluminum additives properties. Also, the first page of output contains some of the preliminary results of calculations, such as the values of the overall propellant volume fraction of oxidizer and density, and many of the control parameters associated with burning rate versus pressure calculations and nonsteady state calculations. These parameters are listed with their actual variable designation, a brief word description and the numerical values associated with the parameters. Whenever either aluminum modeling or erosive burning modeling is employed, additional calculation input information such as that depicted on the first page of output is provided. The following pseudo-propellant variables calculated within the computer program are also presented:

DZERO	the pseudo-propellant oxidizer particle diameter.
BETAF	the fraction of reactants entering into the primary flame.
XSTPD	the primary flame diffusion flame standoff distance.
XSTPF	the primary flame kinetic standoff distance.
XSTAP	the oxidizer monopropellant flame kinetic standoff distance.
XSTFD	the final flame diffusion flame standoff distance.
TF	the final flame adiabatic flame temperature.

TSPF	the percent contribution of the primary flame to the overall energy flux at the propellant surface.
TSFF	the percent contribution of the final flame to the overall energy flux at the propellant surface.
TSAP	the percent contribution of the oxidizer monopropellant flame to the overall energy flux at the propellant surface.
TSQL	surface temperature rise due to oxidizer decomposition.
TSQF	surface temperature rise due to fuel binder pyrolysis.
TSQM	surface temperature rise due to metal liquifaction.
SOXP	ratio of total oxidizer surface area to planar oxidizer surface area.
TSB	the fuel binder surface temperature (ITS2=1).
RATE	the pseudo-propellant linear burning rate.
XNUV	the pseudo-propellant oxidizer volume fraction.
ALFAV	the pseudo-propellant oxidizer mass fraction.
RHOV	the pseudo-propellant density.
FSKP	the pseudo-propellant oxidizer distribution function.
XLAMAP	the oxidizer monopropellant flame zone thermal conductivity.
XLAMPF	the primary flame zone thermal conductivity.
XLAMFF	the final flame zone thermal conductivity.
C	constant of proportionality in St. Robert's burning law.
N	pressure exponent in St. Robert's burning law.

The following parameters are associated with the aluminum particle combustion modeling within the PEM.

VG	hot gas stream velocity, normal to propellant surface.
DAGGL	liguid metal droplet diameter.
TIGN	ignition time referenced from moment of completed emergence.
XIGN	distance above surface at ignition relative to center of aluminum particle.
DLOFF	diameter of aluminum particle at lift off from surface.
VELP	velocity of aluminum particle at moment of ignition.
TCOMB	time required for complete combustion after ignition.
XCOMB	distance above surface at moment of complete combustion.
TSAL	the percent contribution of the aluminum combustion to the overall energy flux at the propellant surface.

The following parameters are associated with the erosive burning combustion modeling within the PEM.

ROUGH	the average roughness height based on oxidizer geometry.
GAMAPF	the primary flame zone mass diffusivity coefficient.
GAMAFF	the final flame zone mass diffusivity coefficient.
R-EROS	the pseudo-propellant erosive burning rate.
R-NEROS	the pseudo-propellant nonerosive burning rate.
EBETA	the pseudo-propellant erosive burning strength.
TSBN	the fuel binder sensible heat.
TAVBL	boundary layer average gas temperature.

XMEW	boundary layer average gas viscosity.
AMWBL	boundary layer average gas molecular weight.

The following parameters are associated with the nonsteady state response modeling within the PEM.

GRAD	surface heat flux.
C(JJ,N)	C parameter for JJth pseudo-propellant (N = 1,4) used in small perturbation response calculations.
PXN	the pseudo-propellant pressure exponent.
NDF	nondimensional frequency.
OMEGA	frequency in cycles per second.
RE(RSP/N)	real part of complex normalized response function.
IM(RSP/N)	imaginary part of complex normalized response function.
RE(RSP)	real part of complex response function.
IM(RSP)	imaginary part of complex response function.
MAG(RSP)	magnitude of complex response function.
PHASE	phase angle in degrees of the complex response function.
MAG(RSP/N)	magnitude of the complex normalized response function.
PXK	value related to the pseudo-propellant's sensitivity of burning rate to changes in initial solid propellant temperature.
PXR	value related to the pseudo-propellant's sensitivity of surface temperature to changes in initial solid propellant temperature.

PXM value related to the pseudo-propellant's sensitivity of surface temperature to changes in combustion pressure (for pressure coupled response) or crossflow velocity (for velocity coupled response).

PXD value equal to $d_1d_4 - d_2d_3$ for pressure coupled response calculations and equal to $h_1h_4 - h_2h_3$ for velocity coupled response calculations.

PXS the pseudo-propellant temperature sensitivity.

ES1 the pseudo-propellant effective surface activation energy calculated via a pressure perturbation for the pressure coupled response and via a crossflow velocity perturbation for the velocity coupled response.

ES2 the pseudo-propellant effective surface activation energy calculated via a initial solid propellant temperature perturbation.

A the Denison and Baum A parameter.

B the Denison and Baum B parameter.

AVV the Denison and Baum A parameter calculated via a perturbation in the initial solid propellant temperature.

PXNE the pseudo-propellant crossflow velocity exponent.

VI. SAMPLE CASES

A. INTRODUCTION

Eleven sample cases are presented in this section to illustrate the applications of the PEM computer program to calculations of both the steady state and the nonsteady state propellant response. For each sample case, a brief discussion of the calculation to be performed is provided. This is followed by a figure depicting the required input data for each case. Finally, the generated computer output is given. In each case, the seven namelist input groupings provide all of the necessary input information. The last sample case, requires formatted data entry in order to generate a plot of the calculated response function versus frequency data. Below is a brief description of these eleven sample cases. Please note that if output is repeated between cases, such output will only be presented once with new output presented for each of the sample cases.

B. SAMPLE CASE NUMBER 1

This case is a typical burning rate versus combustion pressure calculation for a nonaluminized, unimodal propellant. The oxidizer has a mean diameter of 40 microns while the mode width parameter equals two. The total percent of oxidizer is 88 percent with the fuel binder being HTPB. Three pressures are investigated; 34.0136, 68.0272, and 136.0544 atmospheres. After calculations are completed, the pressure exponent is calculated based upon the obtained results.

```
$FLAG $
$PARMST PSTART=34.0136, PSTOP=136.0544, NPRESS=3 $
$PROPDT $
$ALUMDT $
$EROSDT $
$RESPDT $
$OXDIST DBARI(1)=40., SIGMA(1)=2.0, ALFAI(1)=.88, MODES=1 $
```

Figure 2. Data Deck for Sample Case Number 1.

***** PETITE ENSEMBLE MODEL(PEM) INPUT/OUTPUT PARAMETERS *****

TZERO-INITIAL SOLID PROPELLANT TEMPERATURE	294.15	KELVIN			
XALFA-OXIDIZER TOTAL MASS FRACTION	.8800		NPROP-PROPELLANT NUMBER	0	
AOXID-OXIDIZER TYPE	AP		AFUEL-FUEL BINDER TYPE	HTPB	
QL-OXIDIZER HEAT OF DECOMPOSITION	0.00	CAL/GRAM	QFUEL-FUEL HEAT OF PYROLYSIS	433.00	CAL/GRAM
RHOX-OXIDIZER DENSITY	1.950	G/CM**3	RHOF-FUEL DENSITY	.920	G/CM**3
AOX-OXIDIZER DECOMPOSITION FREQ. FACTOR	.166E+05	G/CM**2-S	AF-FUEL PYROLYSIS FREQUENCY FACTOR	.299E+03	G/CM**2-S
EOX-OXIDIZER DECOMPOSITION ACTIV. ENERGY	21000.	CAL/MOLE	EF-FUEL PYROLYSIS ACTIVATION ENERGY	16900.	CAL/MOLE
AAP-OXIDIZER FLAME FREQUENCY FACTOR	2500000.	CM3-G/S-A	APF-PRIMARY FLAME FREQUENCY FACTOR	1400.	CM3-G/S-A
EAP-OXIDIZER FLAME ACTIVATION ENERGY	25000.	CAL/MOLE	EPF-PRIMARY FLAME ACTIVATION ENERGY	15000.	CAL/MOLE
DELAP-OXIDIZER FLAME REACTION ORDER	1.0		DELPF-PRIMARY FLAME REACTION ORDER	1.5	
PFMW-PRIMARY FLAME M.W. (1000 PSIA)	25.99	G/GMOLE	XNUPF-PRIMARY FLAME STOICHIOMETRY VARIABLE	9.30	
FFMW-FINAL FLAME M.W. (1000 PSIA)	26.95	G/GMOLE	XNUFF-FINAL FLAME STOICHIOMETRY VARIABLE	9.30	
CP-GAS PHASE SPECIFIC HEAT CAPACITY	.40	CAL/G-K	CIGN-IGNITION DELAY PROPORTIONALITY VALUE	190.	S-ATM/CM
XLAMB-GAS PHASE THERMAL CONDUCTIVITY	.50000E-05	CAL/CM-S-K	POWD-IGNITION DELAY DIAMETER EXPONENT	.800	
GAMMA-DIFFUSION COEFFICIENT PARAMETER	.760E-05	CM2-A/S-K	POWIG-IGNITION DELAY PRESSURE EXPONENT	.721	
PLAMB-SOLID PHASE THERMAL CONDUCTIVITY	.00030	CAL/CM-S-K	CS-SOLID PHASE SPECIFIC HEAT	.20	
FACTOR-FLAME TEMPERATURE PARAMETER	.50				

PSTART-STARTING PRESSURE (RATE/PRESSURE)	34.0136	ATMS	LIMBES-NUMBER OF TERMS (BURKE SCHUMANN)	40	
PSTOP-STOPPING PRESSURE (RATE/PRESSURE)	136.0544	ATMS	ERRBES-MINIMUM VALUE OF LAST TERM IN SERIES	.100E-06	
NPRESS-NUMBER OF PRESSURES CONSIDERED	3		ESTART-INITIAL N.D. DIFFUSION HEIGHT	.100E+00	
NDPM-NUMBER OF DIAMETERS/MODE-(RATE CAL.)	21		XHUHI-MAX VOLUME FRACTION (BURKE SCHUMANN)	.980	
NXDPM-NUMBER OF DIAMETERS/MODE-(C-CAL.)	201		XHULOW-MIN VOLUME FRACTION (BURKE SCHUMANN)	.300	
UINF-CROSS FLOW VELOCITY-EROSIVE BURNING	0.	CM/SEC	CPRIME-CONSTANT IN PRANDTL MIXING LENGTH EXP.	.16	
YSTART-STARTING VALUE OF Y-COORDINATE(CM)	0.000000		COND-PROP. CONST.-DIFFUSION COEFFICIENT	1.00	
YSTOP-STOPPING VALUE OF Y-COORDINATE(CM)	1.000000		CONC-PROP. CONST.-THERMAL CONDUCTIVITY	1.00	
NSTEP-NUMBER OF STEPS-TURB. VEL. PROFILE	461		ITERO-NUMBER OF EROSIVE BURNING ITERATIONS	20	
INSTEP-STEPS/UNIT LN10(Y-COORDINATE)	100		NCYC-NUMBER OF LOG10 CYCLES USED	5	

PPERD-PRESSURE PERTURBATION (NONSTEADY)	.50	PERCENT	***** METAL PARAMETERS *****		
TPERD-TEMPERATURE PERTURBATION (NONSTEADY)	.50	PERCENT	ALTYPE-ALUMINUM TYPE	NONE	
BFAC-COHEN POSTULATE CONSTANT (MAGNITUDE)	1360.000	MICRON	BETA-MASS FRACTION OF METAL	0.0000	
FFAC-COHEN POSTULATE CONSTANT (FREQUENCY)	4.720		QM-LATENT HEAT OF METAL LIQUIFACTION	96.00	CAL/GRAM
OSTART-STARTING FREQUENCY (NONS. RESPONSE)	10.	HERTZ	RHOM-METAL DENSITY	2.710	G/CM**3
OSTOP-STOPPING FREQUENCY (NONS. RESPONSE)	100000.	HERTZ	DBARM-MEAN DIAMETER OF METAL DISTRIBUTION	6.000	MICRON
NOMEG-NUMBER OF FREQUENCIES CONSIDERED	81		SIGMAM-WIDTH PARAMETER OF METAL DISTRIBUTION	1.0000	

***** CATALYST PARAMETERS *****			***** ADDITIVE PARAMETERS *****		
CATYPE-CATALYST TYPE	NONE				
ALFCAT-MASS FRACTION OF CATALYST	0.0000		ADTYPE-ADDITIVE 1 TYPE	NONE	
SPSUR-SPECIFIC SURFACE OF CATALYST	0.0000	M**2/GRAM	ALFADD-ADDITIVE 1 MASS FRACTION	0.0000	
CAP-AP FLAME FACTOR (EXPONENTIAL)	0.00				
EAP2-AP FLAME FACTOR (ACT. ENERGY)	0.00	CAL/MOLE	ADTYPE-ADDITIVE 2 TYPE	NONE	
CPF-PF FLAME FACTOR (EXPONENTIAL)	14.96		ALFADD-ADDITIVE 2 MASS FRACTION	0.0000	
EPF2-PF FLAME FACTOR (ACT. ENERGY)	2610.00	CAL/MOLE			

XNUT-OXIDIZER VOLUME FRACTION	.77578		CX-VALUE OF C IN VF=C*DZERO**N EXPRESS.	.151E+00	
RHOT-TOTAL PROPELLANT DENSITY	1.71905	G/CM**3	XN-VALUE OF N IN VF=C*DZERO**N EXPRESS.	3.000	
RHOFA-FUEL-ALUMINUM MIXTURE DENSITY	.92000	G/CM**3	MODES-NUMBER OF OXIDIZER MODES	1	

MODE NUMBER	MEAN DIAMETER (DBARI)	MODE WIDTH PARAMETER (SIGMAI)	MASS FRACTION (ALFAI)	MASS FRACTION (CORR)
1	40.000	2.0000	.8800	

PRESSURE IS 500.0 PSIA THE OXID/FUEL BEING CONSIDERED IS AP/ HTPB
INITIAL PROPELLANT TEMPERATURE IS 294.2 DEGREES KELVIN

DZERO (MICRONS)	BETAF	XSTPD (MICRONS)	XSTPF (MICRONS)	XSTAP (MICRONS)	XSTFD (MICRONS)	TF (K)	TS (K)	TSPF ...	TSFF (PERCENT)	TSAP ...	TSQL (K)	TSQF (K)	TSQM (K)	SQXP
3.04	1.000	.978	1.729	3.583	0.000	2956.3	1147.82	100.00	0.00	0.00	0.00	-295.23	0.00	2.547
3.94	1.000	1.299	1.670	3.460	0.000	2956.3	1145.05	100.00	0.00	0.00	0.00	-295.23	0.00	2.514
5.09	.987	1.733	1.595	3.304	.002	2956.3	1141.35	99.32	.57	.11	0.00	-295.23	0.00	2.474
6.59	.677	2.309	1.459	3.023	2.971	2956.3	1133.54	86.45	9.41	4.14	0.00	-295.23	0.00	2.413
8.53	.466	3.099	1.347	2.790	3.493	2956.3	1126.79	71.41	19.09	9.50	0.00	-295.23	0.00	2.355
11.03	.318	4.188	1.243	2.576	4.505	2956.3	1120.28	57.13	26.87	16.00	0.00	-295.23	0.00	2.296
14.27	.216	5.700	1.148	2.378	5.924	2956.3	1113.95	44.42	32.18	23.40	0.00	-295.23	0.00	2.236
18.47	.145	7.817	1.057	2.189	7.916	2956.3	1107.64	33.66	34.80	31.53	0.00	-295.23	0.00	2.173
23.89	.096	10.808	.970	2.010	10.730	2956.3	1101.30	24.89	34.93	40.18	0.00	-295.23	0.00	2.107
30.92	.063	15.075	.888	1.841	14.734	2956.3	1095.04	17.96	33.03	49.01	0.00	-295.23	0.00	2.039
40.00	.041	21.232	.813	1.685	20.491	2956.3	1089.05	12.66	29.69	57.65	0.00	-295.23	0.00	1.968
51.75	.026	30.242	.745	1.544	28.875	2956.3	1083.57	8.71	25.55	65.74	0.00	-295.23	0.00	1.894
66.96	.017	43.622	.685	1.419	41.264	2956.3	1078.85	5.87	21.12	73.01	0.00	-295.23	0.00	1.817
86.64	.011	63.801	.632	1.310	59.858	2956.3	1075.17	3.87	16.83	79.30	0.00	-295.23	0.00	1.735
112.10	.007	94.697	.587	1.216	88.210	2956.3	1072.79	2.51	12.93	84.56	0.00	-295.23	0.00	1.646
145.05	.004	142.634	.548	1.136	132.063	2956.3	1072.01	1.60	9.62	88.79	0.00	-295.23	0.00	1.548
187.67	.003	217.763	.515	1.066	200.672	2956.3	1073.09	1.00	6.94	92.06	0.00	-295.23	0.00	1.439
242.83	.002	336.328	.485	1.005	308.877	2956.3	1076.00	.62	4.89	94.49	0.00	-295.23	0.00	1.321
314.18	.001	525.343	.460	.954	481.353	2956.3	1079.83	.38	3.36	96.26	0.00	-295.23	0.00	1.210
406.51	.001	835.572	.442	.917	764.182	2956.3	1081.96	.23	2.23	97.54	0.00	-295.23	0.00	1.141
525.97	.000	1368.183	.436	.904	1248.695	2956.3	1079.71	.14	1.39	98.47	0.00	-295.23	0.00	1.148

DZERO (MICRONS)	RATE (CM/SEC)	XNUV	ALFAV	RHOV (G/CM**3)	FSKP	XLAMAP (CAL/CM-S-K)	XLAMPF (CAL/CM-S-K)	XLAMFF (CAL/CM-S-K)
3.04	2.1737	.7758	.8800	1.7190	.0005	.1784E-03	.2265E-03	.2265E-03
3.94	2.0987	.7758	.8800	1.7190	.0019	.1783E-03	.2264E-03	.2264E-03
5.09	2.0045	.7758	.8800	1.7190	.0061	.1781E-03	.2263E-03	.2263E-03
6.59	1.8339	.7758	.8800	1.7190	.0172	.1779E-03	.2261E-03	.2261E-03
8.53	1.6926	.7758	.8800	1.7190	.0421	.1776E-03	.2259E-03	.2259E-03
11.03	1.5628	.7758	.8800	1.7190	.0901	.1774E-03	.2257E-03	.2257E-03
14.27	1.4424	.7758	.8800	1.7190	.1677	.1772E-03	.2256E-03	.2256E-03
18.47	1.3281	.7758	.8800	1.7190	.2720	.1769E-03	.2254E-03	.2254E-03
23.89	1.2192	.7758	.8800	1.7190	.3842	.1767E-03	.2252E-03	.2252E-03
30.92	1.1168	.7758	.8800	1.7190	.4727	.1765E-03	.2250E-03	.2250E-03
40.00	1.0222	.7758	.8800	1.7190	.5065	.1763E-03	.2249E-03	.2249E-03
51.75	.9368	.7758	.8800	1.7190	.4727	.1761E-03	.2247E-03	.2247E-03
66.96	.8610	.7758	.8800	1.7190	.3842	.1759E-03	.2246E-03	.2246E-03
86.64	.7949	.7758	.8800	1.7190	.2720	.1758E-03	.2245E-03	.2245E-03
112.10	.7378	.7758	.8800	1.7190	.1677	.1757E-03	.2244E-03	.2244E-03
145.05	.6889	.7758	.8800	1.7190	.0901	.1757E-03	.2244E-03	.2244E-03
187.67	.6467	.7758	.8800	1.7190	.0421	.1757E-03	.2244E-03	.2244E-03
242.83	.6099	.7758	.8800	1.7190	.0172	.1758E-03	.2245E-03	.2245E-03
314.18	.5785	.7758	.8800	1.7190	.0061	.1760E-03	.2246E-03	.2246E-03
406.51	.5561	.7758	.8800	1.7190	.0019	.1760E-03	.2247E-03	.2247E-03
525.97	.5483	.7758	.8800	1.7190	.0005	.1760E-03	.2246E-03	.2246E-03

MODE NUMBER 1 SERIES RATE = 1.0527 CM/SEC PARALLEL RATE = 1.0017 CM/SEC BETAR = .1225

PRESSURE IS 1000.0 PSIA THE OXID/FUEL BEING CONSIDERED IS AP/ HTPB
INITIAL PROPELLANT TEMPERATURE IS 294.2 DEGREES KELVIN

DZERO (MICRONS)	BETAF	XSTPD (MICRONS)	XSTPF (MICRONS)	XSTAP (MICRONS)	XSTFD (MICRONS)	TF (K)	TS (K)	TSPF ...	TSFF (PERCENT)	TSAP ...	TSQL (K)	TSQF (K)	TSQM (K)	SOXP
3.04	1.000	1.033	.920	2.670	0.000	2998.3	1191.64	100.00	0.00	0.00	0.00	-295.23	0.00	2.829
3.94	1.000	1.384	.866	2.515	0.000	2998.3	1185.97	100.00	0.00	0.00	0.00	-295.23	0.00	2.780
5.09	.818	1.858	.798	2.318	.526	2998.3	1178.23	92.73	5.89	1.37	0.00	-295.23	0.00	2.718
6.59	.540	2.483	.704	2.044	2.845	2998.3	1166.05	81.77	11.92	6.31	0.00	-295.23	0.00	2.631
8.53	.360	3.350	.633	1.838	3.639	2998.3	1156.17	66.54	20.35	13.11	0.00	-295.23	0.00	2.557
11.03	.239	4.556	.573	1.662	4.760	2998.3	1147.04	51.82	26.87	21.31	0.00	-295.23	0.00	2.487
14.27	.158	6.245	.519	1.507	6.344	2998.3	1138.37	39.01	30.62	30.37	0.00	-295.23	0.00	2.418
18.47	.104	8.634	.471	1.367	8.587	2998.3	1130.00	28.52	31.63	39.85	0.00	-295.23	0.00	2.350
23.89	.068	12.045	.427	1.241	11.788	2998.3	1121.92	20.32	30.38	49.30	0.00	-295.23	0.00	2.282
30.92	.044	16.976	.389	1.128	16.402	2998.3	1114.25	14.13	27.54	58.33	0.00	-295.23	0.00	2.213
40.00	.028	24.207	.354	1.029	23.138	2998.3	1107.14	9.62	23.78	66.61	0.00	-295.23	0.00	2.145
51.75	.018	34.972	.325	.942	33.121	2998.3	1100.78	6.41	19.67	73.92	0.00	-295.23	0.00	2.077
66.96	.011	51.267	.299	.868	48.161	2998.3	1095.35	4.20	15.63	80.18	0.00	-295.23	0.00	2.007
86.64	.007	76.346	.278	.806	71.215	2998.3	1091.07	2.70	11.95	85.35	0.00	-295.23	0.00	1.934
112.10	.004	115.551	.260	.754	107.140	2998.3	1088.15	1.71	8.80	89.49	0.00	-295.23	0.00	1.858
145.05	.003	177.640	.245	.711	163.919	2998.3	1086.80	1.07	6.27	92.67	0.00	-295.23	0.00	1.773
187.67	.002	276.805	.233	.675	254.521	2998.3	1087.20	.66	4.34	95.01	0.00	-295.23	0.00	1.678
242.83	.001	435.573	.222	.644	399.594	2998.3	1089.53	.40	2.94	96.66	0.00	-295.23	0.00	1.568
314.18	.001	688.888	.212	.615	631.268	2998.3	1093.84	.24	1.97	97.79	0.00	-295.23	0.00	1.440
406.51	.000	1091.049	.202	.586	999.569	2998.3	1099.82	.15	1.32	98.54	0.00	-295.23	0.00	1.303
525.97	.000	1737.132	.193	.561	1591.776	2998.3	1105.73	.09	.87	99.04	0.00	-295.23	0.00	1.183

DZERO (MICRONS)	RATE (CM/SEC)	XNUV	ALFAV	RHOV (G/CM**3)	FSKP	XLAMAP (CAL/CM-S-K)	XLAMPF (CAL/CM-S-K)	XLAMFF (CAL/CM-S-K)
3.04	3.3883	.7758	.8800	1.7190	.0005	.1801E-03	.2289E-03	.2289E-03
3.94	3.1912	.7758	.8800	1.7190	.0019	.1799E-03	.2287E-03	.2287E-03
5.09	2.9420	.7758	.8800	1.7190	.0061	.1797E-03	.2285E-03	.2285E-03
6.59	2.5937	.7758	.8800	1.7190	.0172	.1792E-03	.2282E-03	.2282E-03
8.53	2.3330	.7758	.8800	1.7190	.0421	.1789E-03	.2279E-03	.2279E-03
11.03	2.1096	.7758	.8800	1.7190	.0901	.1786E-03	.2276E-03	.2276E-03
14.27	1.9123	.7758	.8800	1.7190	.1677	.1783E-03	.2274E-03	.2274E-03
18.47	1.7347	.7758	.8800	1.7190	.2720	.1780E-03	.2272E-03	.2272E-03
23.89	1.5747	.7758	.8800	1.7190	.3842	.1777E-03	.2269E-03	.2269E-03
30.92	1.4316	.7758	.8800	1.7190	.4727	.1774E-03	.2267E-03	.2267E-03
40.00	1.3055	.7758	.8800	1.7190	.5065	.1772E-03	.2265E-03	.2265E-03
51.75	1.1959	.7758	.8800	1.7190	.4727	.1769E-03	.2264E-03	.2264E-03
66.96	1.1020	.7758	.8800	1.7190	.3842	.1768E-03	.2262E-03	.2262E-03
86.64	1.0229	.7758	.8800	1.7190	.2720	.1766E-03	.2261E-03	.2261E-03
112.10	.9570	.7758	.8800	1.7190	.1677	.1765E-03	.2260E-03	.2260E-03
145.05	.9026	.7758	.8800	1.7190	.0901	.1765E-03	.2260E-03	.2260E-03
187.67	.8572	.7758	.8800	1.7190	.0421	.1765E-03	.2260E-03	.2260E-03
242.83	.8176	.7758	.8800	1.7190	.0172	.1765E-03	.2260E-03	.2260E-03
314.18	.7805	.7758	.8800	1.7190	.0061	.1767E-03	.2262E-03	.2262E-03
406.51	.7441	.7758	.8800	1.7190	.0019	.1769E-03	.2263E-03	.2263E-03
525.97	.7115	.7758	.8800	1.7190	.0005	.1771E-03	.2265E-03	.2265E-03

MODE NUMBER 1 SERIES RATE = 1.3638 CM/SEC PARALLEL RATE = 1.2926 CM/SEC BETAR = .3591

PRESSURE IS 2000.0 PSIA THE OXID/FUEL BEING CONSIDERED IS AP/ HTPB
INITIAL PROPELLANT TEMPERATURE IS 294.2 DEGREES KELVIN

DZERO	BETAF	XSTPD	XSTPF	XSTAP	XSTFD	TF	TS	TSPF	TSFF	TSAP	TSQL	TSQF	TSQM	SOXP
(MICRONS)		(MICRONS)	(MICRONS)	(MICRONS)	(MICRONS)	(K)	(K)	...	(PERCENT)	...	(K)	(K)	(K)	
3.04	1.000	1.106	.460	1.868	0.000	3038.4	1236.53	100.00	0.00	0.00	0.00	-295.23	0.00	3.000
3.94	.858	1.488	.417	1.694	.239	3038.4	1222.52	95.35	3.88	.77	0.00	-295.23	0.00	3.000
5.09	.554	1.984	.359	1.458	2.276	3038.4	1205.43	85.62	9.18	5.20	0.00	-295.23	0.00	2.918
6.59	.362	2.671	.316	1.281	2.898	3038.4	1192.36	69.99	17.70	12.31	0.00	-295.23	0.00	2.824
8.53	.237	3.627	.281	1.139	3.784	3038.4	1180.71	54.16	24.66	21.18	0.00	-295.23	0.00	2.740
11.03	.155	4.968	.251	1.020	5.041	3038.4	1170.03	40.29	28.78	30.93	0.00	-295.23	0.00	2.661
14.27	.101	6.866	.226	.916	6.825	3038.4	1159.98	29.07	30.02	40.91	0.00	-295.23	0.00	2.587
18.47	.065	9.580	.203	.826	9.374	3038.4	1150.44	20.44	28.92	50.64	0.00	-295.23	0.00	2.514
23.89	.042	13.507	.184	.747	13.055	3038.4	1141.43	14.05	26.22	59.74	0.00	-295.23	0.00	2.445
30.92	.027	19.271	.167	.678	18.436	3038.4	1133.06	9.46	22.61	67.93	0.00	-295.23	0.00	2.377
40.00	.017	27.863	.152	.619	26.421	3038.4	1125.46	6.25	18.67	75.08	0.00	-295.23	0.00	2.311
51.75	.010	40.888	.140	.569	38.473	3038.4	1118.78	4.06	14.80	81.14	0.00	-295.23	0.00	2.247
66.96	.007	60.977	.130	.528	56.989	3038.4	1113.19	2.60	11.27	86.13	0.00	-295.23	0.00	2.184
86.64	.004	92.495	.122	.494	85.947	3038.4	1108.84	1.64	8.26	90.10	0.00	-295.23	0.00	2.121
112.10	.002	142.690	.115	.466	131.966	3038.4	1105.88	1.02	5.84	93.14	0.00	-295.23	0.00	2.055
145.05	.001	223.541	.109	.445	206.002	3038.4	1104.39	.63	4.00	95.38	0.00	-295.23	0.00	1.985
187.67	.001	354.595	.105	.427	325.968	3038.4	1104.40	.38	2.66	96.95	0.00	-295.23	0.00	1.906
242.83	.001	567.215	.101	.412	520.654	3038.4	1105.93	.23	1.75	98.02	0.00	-295.23	0.00	1.814
314.18	.000	910.599	.098	.398	835.330	3038.4	1109.03	.14	1.13	98.73	0.00	-295.23	0.00	1.705
406.51	.000	1459.759	.094	.382	1339.215	3038.4	1113.80	.08	.74	99.18	0.00	-295.23	0.00	1.575
525.97	.000	2326.085	.090	.365	2135.426	3038.4	1120.24	.05	.49	99.46	0.00	-295.23	0.00	1.425

DZERO	RATE	XNUV	ALFAV	RHOV	FSKP	XLAMAP	XLAMPF	XLAMFF
(MICRONS)	(CM/SEC)			(G/CM**3)		(CAL/CM-S-K)	(CAL/CM-S-K)	(CAL/CM-S-K)
3.04	4.9575	.7758	.8800	1.7190	.0005	.1819E-03	.2312E-03	.2312E-03
3.94	4.4950	.7758	.8800	1.7190	.0019	.1814E-03	.2308E-03	.2308E-03
5.09	3.8675	.7758	.8800	1.7190	.0061	.1808E-03	.2303E-03	.2303E-03
6.59	3.4002	.7758	.8800	1.7190	.0172	.1804E-03	.2300E-03	.2300E-03
8.53	3.0226	.7758	.8800	1.7190	.0421	.1800E-03	.2297E-03	.2297E-03
11.03	2.7057	.7758	.8800	1.7190	.0901	.1796E-03	.2294E-03	.2294E-03
14.27	2.4317	.7758	.8800	1.7190	.1677	.1793E-03	.2291E-03	.2291E-03
18.47	2.1918	.7758	.8800	1.7190	.2720	.1789E-03	.2288E-03	.2288E-03
23.89	1.9818	.7758	.8800	1.7190	.3842	.1786E-03	.2286E-03	.2286E-03
30.92	1.7995	.7758	.8800	1.7190	.4727	.1783E-03	.2283E-03	.2283E-03
40.00	1.6429	.7758	.8800	1.7190	.5065	.1781E-03	.2281E-03	.2281E-03
51.75	1.5104	.7758	.8800	1.7190	.4727	.1778E-03	.2280E-03	.2280E-03
66.96	1.4000	.7758	.8800	1.7190	.3842	.1776E-03	.2278E-03	.2278E-03
86.64	1.3098	.7758	.8800	1.7190	.2720	.1775E-03	.2277E-03	.2277E-03
112.10	1.2374	.7758	.8800	1.7190	.1677	.1774E-03	.2276E-03	.2276E-03
145.05	1.1797	.7758	.8800	1.7190	.0901	.1773E-03	.2276E-03	.2276E-03
187.67	1.1329	.7758	.8800	1.7190	.0421	.1773E-03	.2276E-03	.2276E-03
242.83	1.0927	.7758	.8800	1.7190	.0172	.1774E-03	.2276E-03	.2276E-03
314.18	1.0548	.7758	.8800	1.7190	.0061	.1775E-03	.2277E-03	.2277E-03
406.51	1.0149	.7758	.8800	1.7190	.0019	.1777E-03	.2278E-03	.2278E-03
525.97	.9695	.7758	.8800	1.7190	.0005	.1779E-03	.2280E-03	.2280E-03

MODE NUMBER 1 SERIES RATE = 1.7297 CM/SEC PARALLEL RATE = 1.6421 CM/SEC BETAR = .6486

PRES ATMS	PRES PSIA	BR CM/SEC	BR IN/SEC
34.01	500.0	1.0527	.4144
68.03	1000.0	1.3638	.5369
136.05	2000.0	1.7297	.6810

FROM THE ABOVE BURNING RATE VERSUS PRESSURE DATA
A LEAST SQUARE FIT IS USED TO DETERMINE C AND N
IN ST ROBERTS BURNING RATE LAW-- R = C*P**N

C =   .44887E-01 IN**(1+2N)/SEC-LB**N
N =   .35824E+00

COEFFICIENT OF DETERMINATION =   .99938E+00

C. SAMPLE CASE NUMBER 2

This case represents an aluminum combustion calculation. Again, the oxidizer distribution is unimodal with a mean oxidizer diameter of 40 microns and a mode width parameter equal to two. The mass fractions of oxidizer and aluminum are .68 and .20, respectively. The aluminum particles have a diameter of 24 microns. In this particular case, the adiabatic flame temperatures and molecular weights of the combustion products must be inputed since such information is unavailable in FLAMET. As discussed previously, the NASA Thermochemistry Program has been employed to calculate these values for the propellant formulation considered at the three combustion pressures required. The flame temperatures have been calculated for an initial temperature of 298.15 K while the default initial temperature is 294.15 K. Therefore, a temperature correction will be made to this data.

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$FLAG ITFAD=1 $

$PARMST $

$PROPDT TF1=2428.2, TF2=2444.0, TF3=2453.9, AMW1=30.431, AMW2=30.511,
        AMW3=30.559 $

$ALUMDT BETA=.20, DBARM=24., IALUM=1 $

$EROSDT $

$RESPDT $

$OXDIST DBARI(1)=40., SIGMAI(1)=2.0, ALFAI(1)=.68, MODES=1 $
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Figure 3. Data Deck for Sample Case Number 2.

***** PETITE ENSEMBLE MODEL(PEM) INPUT/OUTPUT PARAMETERS *****

TZERO-INITIAL SOLID PROPELLANT TEMPERATURE	294.15	KELVIN			
XALFA-OXIDIZER TOTAL MASS FRACTION	.6800		NPROP-PROPELLANT NUMBER	0	
AOXID-OXIDIZER TYPE	AP		AFUEL-FUEL BINDER TYPE	HTPB	
QL-OXIDIZER HEAT OF DECOMPOSITION	0.00	CAL/GRAM	QFUEL-FUEL HEAT OF PYROLYSIS	433.00	CAL/GRAM
RHOX-OXIDIZER DENSITY	1.950	G/CM**3	RHOF-FUEL DENSITY	.920	G/CM**3
AOX-OXIDIZER DECOMPOSITION FREQ. FACTOR	.166E+05	G/CM**2-S	AF-FUEL PYROLYSIS FREQUENCY FACTOR	.239E+03	G/CM**2-S
EOX-OXIDIZER DECOMPOSITION ACTIV. ENERGY	21000.	CAL/MOLE	EF-FUEL PYROLYSIS ACTIVATION ENERGY	16900.	CAL/MOLE
AAP-OXIDIZER FLAME FREQUENCY FACTOR	2500000.	CM3-G/S-A	APF-PRIMARY FLAME FREQUENCY FACTOR	1400.	CM3-G/S-A
EAP-OXIDIZER FLAME ACTIVATION ENERGY	25000.	CAL/MOLE	EPF-PRIMARY FLAME ACTIVATION ENERGY	15000.	CAL/MOLE
DELAP-OXIDIZER FLAME REACTION ORDER	1.0		DELPF-PRIMARY FLAME REACTION ORDER	1.5	
PFMW-PRIMARY FLAME M.W. (1000 PSIA)	30.51	G/GMOLE	XNUPF-PRIMARY FLAME STOICHIOMETRY VARIABLE	9.30	
FFMW-FINAL FLAME M.W. (1000 PSIA)	29.21	G/GMOLE	XNUFF-FINAL FLAME STOICHIOMETRY VARIABLE	9.30	
CP-GAS PHASE SPECIFIC HEAT CAPACITY	.40	CAL/G-K	CIGN-IGNITION DELAY PROPORTIONALITY VALUE	190.	S-ATM/CM
XLAMB-GAS PHASE THERMAL CONDUCTIVITY	.50000E-05	CAL/CM-S-K	POWD-IGNITION DELAY DIAMETER EXPONENT	.800	
GAMMA-DIFFUSION COEFFICIENT PARAMETER	.760E-05	CM2-A/S-K	POWIG-IGNITION DELAY PRESSURE EXPONENT	.721	
PLAMB-SOLID PHASE THERMAL CONDUCTIVITY	.00030	CAL/CM-S-K	CS-SOLID PHASE SPECIFIC HEAT	.20	
FACTOR-FLAME TEMPERATURE PARAMETER	.50				

PSTART-STARTING PRESSURE (RATE/PRESSURE)	68.0272	ATMS	LIMBES-NUMBER OF TERMS (BURKE SCHUMANN)	40	
PSTOP-STOPPING PRESSURE (RATE/PRESSURE)	68.0272	ATMS	ERRBES-MINIMUM VALUE OF LAST TERM IN SERIES	.100E-06	
NPRESS-NUMBER OF PRESSURES CONSIDERED	1		ESTART-INITIAL N.D. DIFFUSION HEIGHT	.100E+00	
NDPM-NUMBER OF DIAMETERS/MODE-(RATE CAL.)	21		XHUHI-MAX VOLUME FRACTION (BURKE SCHUMANN)	.980	
NXDPM-NUMBER OF DIAMETERS/MODE-(C-CAL.)	201		XHULOW-MIN VOLUME FRACTION (BURKE SCHUMANN)	.300	
UINF-CROSS FLOW VELOCITY-EROSIVE BURNING	0.	CM/SEC	CPRIME-CONSTANT IN PRANDTL MIXING LENGTH EXP.	.16	
YSTART-STARTING VALUE OF Y-COORDINATE(CM)	0.000000		COND-PROP. CONST.-DIFFUSION COEFFICIENT	1.00	
YSTOP-STOPPING VALUE OF Y-COORDINATE(CM)	1.000000		CONC-PROP. CONST.-THERMAL CONDUCTIVITY	1.00	
NSTEP-NUMBER OF STEPS-TURB. VEL. PROFILE	461		ITERO-NUMBER OF EROSIVE BURNING ITERATIONS	20	
INSTEP-STEPS/UNIT LN10(Y-COORDINATE)	100		NCYC-NUMBER OF LOG10 CYCLES USED	5	

PPERD-PRESSURE PERTURBATION (NONSTEADY)	.50	PERCENT	***** METAL PARAMETERS *****		
TPERD-TEMPERATURE PERTURBATION (NONSTEADY)	.50	PERCENT	ALTYPE-ALUMINUM TYPE	AL	
BFAC-COHEN POSTULATE CONSTANT (MAGNITUDE)	1360.000	MICRON	BETA-MASS FRACTION OF METAL	.2000	
FFAC-COHEN POSTULATE CONSTANT (FREQUENCY)	4.720		QM-LATENT HEAT OF METAL LIQUIFACTION	96.00	CAL/GRAM
OSTART-STARTING FREQUENCY (NONS. RESPONSE)	10.	HERTZ	RHOM-METAL DENSITY	2.710	G/CM**3
OSTOP-STOPPING FREQUENCY (NONS. RESPONSE)	100000.	HERTZ	DBARM-MEAN DIAMETER OF METAL DISTRIBUTION	24.000	MICRON
NOMEG-NUMBER OF FREQUENCIES CONSIDERED	81		SIGMAM-WIDTH PARAMETER OF METAL DISTRIBUTION	1.0000	

***** CATALYST PARAMETERS *****			***** ADDITIVE PARAMETERS *****		
CATYPE-CATALYST TYPE	NONE				
ALFCAT-MASS FRACTION OF CATALYST	0.0000		ADTYPE-ADDITIVE 1 TYPE	NONE	
SPSUR-SPECIFIC SURFACE OF CATALYST	0.0000	M**2/GRAM	ALFADD-ADDITIVE 1 MASS FRACTION	0.0000	
CAP-AP FLAME FACTOR (EXPONENTIAL)	0.00				
EAP2-AP FLAME FACTOR (ACT. ENERGY)	0.00	CAL/MOLE	ADTYPE-ADDITIVE 2 TYPE	NONE	
CPF-PF FLAME FACTOR (EXPONENTIAL)	14.96		ALFADD-ADDITIVE 2 MASS FRACTION	0.0000	
EPF2-PF FLAME FACTOR (ACT. ENERGY)	2610.00	CAL/MOLE			

XNUT-OXIDIZER VOLUME FRACTION	.63033		CX-VALUE OF C IN VF=C*DZERO**N EXPRESS.	.307E+00	
RHOT-TOTAL PROPELLANT DENSITY	1.80758	G/CM**3	XN-VALUE OF N IN VF=C*DZERO**N EXPRESS.	3.000	
RHOFA-FUEL-ALUMINUM MIXTURE DENSITY	1.56472	G/CM**3	MODES-NUMBER OF OXIDIZER MODES	1	

MODE NUMBER	MEAN DIAMETER (DBARI)	MODE WIDTH PARAMETER (SIGMAI)	MASS FRACTION (ALFAI)	MASS FRACTION (CORR)
1	40.000	2.0000	.6800	

PRESSURE IS 1000.0 PSIA THE OXID/FUEL BEING CONSIDERED IS AP/ HTPB
INITIAL PROPELLANT TEMPERATURE IS 294.2 DEGREES KELVIN

DZERO (MICRONS)	BETAF	XSTPD (MICRONS)	XSTPF (MICRONS)	XSTAP (MICRONS)	XSTFD (MICRONS)	TF (K)	TS (K)	TSPF ...	TSFF (PERCENT)	TSAP ...	TSQL (K)	TSQF (K)	TSQM (K)	SOXP
3.04	.868	.831	1.134	1.856	.114	2442.0	1149.54	83.48	6.71	1.89	0.00	-382.06	-374.55	2.588
3.94	.609	1.103	1.055	1.727	1.389	2442.0	1142.90	68.36	16.08	7.11	0.00	-382.06	-374.10	2.540
5.09	.430	1.476	.998	1.634	1.672	2442.0	1137.98	53.74	25.25	12.14	0.00	-382.06	-373.73	2.501
6.59	.304	1.993	.953	1.559	2.170	2442.0	1134.03	41.20	30.63	16.74	0.00	-382.06	-373.42	2.466
8.53	.211	2.705	.895	1.465	2.861	2442.0	1128.70	31.45	34.59	21.97	0.00	-382.06	-372.96	2.421
11.03	.144	3.697	.836	1.368	3.829	2442.0	1122.89	23.64	36.28	27.46	0.00	-382.06	-372.43	2.373
14.27	.097	5.089	.775	1.268	5.193	2442.0	1116.52	17.46	35.96	33.25	0.00	-382.06	-371.80	2.321
18.47	.064	7.056	.713	1.167	7.124	2442.0	1109.64	12.65	33.98	39.23	0.00	-382.06	-371.06	2.265
23.89	.042	9.859	.653	1.069	9.877	2442.0	1102.46	8.97	30.75	45.20	0.00	-382.06	-370.24	2.207
30.92	.027	13.889	.596	.975	13.835	2442.0	1095.13	6.23	26.82	50.96	0.00	-382.06	-369.34	2.147
40.00	.017	19.759	.543	.889	19.592	2442.0	1087.97	4.24	22.59	56.28	0.00	-382.06	-368.41	2.085
51.75	.011	28.430	.496	.812	28.085	2442.0	1081.25	2.83	18.43	61.00	0.00	-382.06	-367.49	2.024
66.96	.007	41.439	.455	.745	40.804	2442.0	1075.20	1.86	14.56	65.07	0.00	-382.06	-366.61	1.961
86.64	.004	61.308	.420	.688	60.204	2442.0	1070.12	1.20	11.12	68.43	0.00	-382.06	-365.85	1.898
112.10	.003	92.002	.391	.639	90.135	2442.0	1065.99	.76	8.25	71.21	0.00	-382.06	-365.21	1.832
145.05	.002	140.092	.366	.598	136.989	2442.0	1063.05	.48	5.94	73.42	0.00	-382.06	-364.75	1.762
187.67	.001	216.086	.344	.563	211.003	2442.0	1061.36	.30	4.17	75.15	0.00	-382.06	-364.48	1.686
242.83	.001	336.555	.325	.532	328.339	2442.0	1060.91	.18	2.88	76.50	0.00	-382.06	-364.41	1.600
314.18	.000	527.048	.308	.504	513.948	2442.0	1061.63	.11	1.97	77.58	0.00	-382.06	-364.52	1.504
406.51	.000	826.370	.291	.476	805.779	2442.0	1063.32	.07	1.34	78.46	0.00	-382.06	-364.79	1.398
525.97	.000	1294.921	.274	.448	1262.907	2442.0	1065.63	.04	.92	79.21	0.00	-382.06	-365.16	1.288

DZERO (MICRONS)	RATE (CM/SEC)	XNUU	ALFAU	RHOU (G/CM**3)	FSKP	XLAMAP (CAL/CM-S-K)	XLAMPF (CAL/CM-S-K)	XLAMFF (CAL/CM-S-K)
3.04	2.2398	.6303	.6800	1.8076	.0004	.1787E-03	.2119E-03	.2119E-03
3.94	2.0842	.6303	.6800	1.8076	.0015	.1784E-03	.2117E-03	.2117E-03
5.09	1.9715	.6303	.6800	1.8076	.0047	.1783E-03	.2115E-03	.2115E-03
6.59	1.8816	.6303	.6800	1.8076	.0133	.1781E-03	.2114E-03	.2114E-03
8.53	1.7683	.6303	.6800	1.8076	.0326	.1779E-03	.2113E-03	.2113E-03
11.03	1.6513	.6303	.6800	1.8076	.0696	.1777E-03	.2111E-03	.2111E-03
14.27	1.5306	.6303	.6800	1.8076	.1296	.1775E-03	.2109E-03	.2109E-03
18.47	1.4086	.6303	.6800	1.8076	.2102	.1773E-03	.2107E-03	.2107E-03
23.89	1.2898	.6303	.6800	1.8076	.2969	.1770E-03	.2105E-03	.2105E-03
30.92	1.1766	.6303	.6800	1.8076	.3653	.1767E-03	.2103E-03	.2103E-03
40.00	1.0727	.5303	.6800	1.8076	.3914	.1765E-03	.2101E-03	.2101E-03
51.75	.9800	.6303	.6800	1.8076	.3653	.1763E-03	.2099E-03	.2099E-03
66.96	.8990	.6303	.6800	1.8076	.2969	.1760E-03	.2097E-03	.2097E-03
86.64	.8303	.6303	.6800	1.8076	.2102	.1759E-03	.2095E-03	.2095E-03
112.10	.7715	.6303	.6800	1.8076	.1296	.1757E-03	.2094E-03	.2094E-03
145.05	.7219	.6303	.6800	1.8076	.0696	.1756E-03	.2093E-03	.2093E-03
187.67	.6797	.6303	.6800	1.8076	.0326	.1755E-03	.2093E-03	.2093E-03
242.83	.6425	.6303	.6800	1.8076	.0133	.1755E-03	.2093E-03	.2093E-03
314.18	.6080	.6303	.6800	1.8076	.0047	.1756E-03	.2093E-03	.2093E-03
406.51	.5740	.6303	.6800	1.8076	.0015	.1756E-03	.2093E-03	.2093E-03
525.97	.5404	.6303	.6800	1.8076	.0004	.1757E-03	.2094E-03	.2094E-03

MODE NUMBER 1 SERIES RATE = 1.1068 CM/SEC PARALLEL RATE = 1.0516 CM/SEC BETAR = .1593

***** ALUMINUM COMBUSTION PEM INPUT/OUTPUT PARAMETERS *****

DBARM-MEAN DIAMETER OF METAL	24.000 MICRONS	BETA-MASS FRACTION OF METAL	.2000
BETAC-POWER LAW BURNING RATE CONSTANT	.0040 CM**2/SEC	DELHR-METAL HEAT OF COMBUSTION	1800.00 CAL/GRAM
CPM-METAL SPECIFIC HEAT	.21400 CAL/GRAM-K	G-GRAVITATIONAL CONSTANT	980.00 CM/SEC**2
RHOM-METAL DENSITY (SOLID)	2.710 G/CM**3	RHOL-METAL DENSITY (LIQUID)	2.350 G/CM**3
TMELT-METAL MELTING TEMPERATURE (K)	933.0	DELC-COMBUSTION LAW DIAMETER EXPONENT	2.00
TSMELT-METAL OXIDE MELTING TEMP. (K)	2320.0	IALST-NUMBER OF STEPS-EMERGENCE	100
GSUR-SURFACE TENSION	0.00 CM/SEC**2	IMET-NUMBER OF STEPS IN METAL INTEGRATION	30

DZERO (MICRONS)	RATE (CM/SEC)	VG (CM/SEC)	DAGGL (MICRONS)	TIGN (MSEC)	XIGN (MICRONS)	DLOFF (MICRONS)	VELP (CM/SEC)	TCOMB (MSEC)	XCOMB (MICRONS)	TSAL (PC)
3.04	2.2398	18.05	25.17	.127	1.64	25.17	2.59	1.584	179.66	7.911
3.94	2.0842	17.29	25.17	.132	1.70	25.17	2.57	1.584	172.11	8.449
5.09	1.9715	16.74	25.17	.136	1.74	25.17	2.55	1.584	166.68	8.867
6.59	1.8816	16.31	25.17	-.000	-.00	25.17	0.00	1.584	146.77	11.430
8.53	1.7683	15.74	25.17	-.000	-.00	25.17	0.00	1.584	141.16	11.991
11.03	1.6513	15.14	25.17	-.000	-.00	25.17	0.00	1.584	135.23	12.623
14.27	1.5306	14.50	25.17	-.000	-.00	25.17	0.00	1.584	128.94	13.339
18.47	1.4086	13.83	25.17	-.000	-.00	25.17	0.00	1.584	122.37	14.140
23.89	1.2858	13.16	25.17	-.174	-.25	25.17	0.00	1.584	115.54	15.083
30.92	1.1766	12.50	25.17	-.183	-.25	25.17	0.00	1.584	109.07	15.985
40.00	1.0727	11.87	25.17	-.192	-.25	25.17	0.00	1.584	103.02	16.864
51.75	.9800	11.31	25.17	-.202	-.25	25.17	0.00	1.584	97.56	17.740
66.96	.8990	10.82	25.17	-.211	-.25	25.17	0.00	1.584	92.82	18.516
86.64	.8303	10.42	25.17	-.438	-.50	25.17	0.00	1.584	88.71	19.253
112.10	.7715	10.11	25.17	-.452	-.50	25.17	0.00	1.584	85.67	19.783
145.05	.7219	9.89	25.17	-.462	-.50	25.17	0.00	1.584	83.55	20.161
187.67	.6797	9.76	25.17	-.468	-.50	25.17	0.00	1.584	82.34	20.378
242.83	.6425	9.73	25.17	-.470	-.50	25.17	0.00	1.584	82.03	20.434
314.18	.6080	9.78	25.17	-.467	-.50	25.17	0.00	1.584	82.54	20.343
406.51	.5740	9.91	25.17	-.461	-.50	25.17	0.00	1.584	83.74	20.126
525.97	.5404	10.08	25.17	-.453	-.50	25.17	0.00	1.584	85.41	19.830

D. SAMPLE CASE NUMBER 3

This case represents an erosive burning rate calculation. The propellant oxidizer distribution is unimodal with a mean diameter of 40 microns and a mode width parameter equal to two. The oxidizer mass fraction is equal to .88 and the value of the crossflow velocity is 20000 centimeter per second. All other default values are assumed. The output corresponding to this sample case illustrates the convergence routine employed in order to determine the proper value of the erosive burning rate for the given propellant formulation. Five iterations were involved until the burning rate used to calculate the transport property enhancement due to turbulence matched the resulting burning rate. Part of the output consists of the final velocity and resistivity profiles of the turbulent boundary layer.

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$FLAG $

$PARMST $

$PROPDT $

$ALUMDT $

$EROSDT UINF=20000. $

$RESPDT $

$OXDIST DBARI(1)=40., SIGMAI(1)=2.0, ALFAI(1)=.88, MODES=1 $
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Figure 4. Data Deck for Sample Case Number 3.

***** PETITE ENSEMBLE MODEL(PEM) INPUT/OUTPUT PARAMETERS *****

TZERO-INITIAL SOLID PROPELLANT TEMPERATURE	294.15	KELVIN			
XALFA-OXIDIZER TOTAL MASS FRACTION	.8800		NPROP-PROPELLANT NUMBER	0	
AOXID-OXIDIZER TYPE	AP		AFUEL-FUEL BINDER TYPE	HTPB	
QL-OXIDIZER HEAT OF DECOMPOSITION	0.00	CAL/GRAM	QFUEL-FUEL HEAT OF PYROLYSIS	433.00	CAL/GRAM
RHOX-OXIDIZER DENSITY	1.950	G/CM**3	RHOF-FUEL DENSITY	.920	G/CM**3
AOX-OXIDIZER DECOMPOSITION FREQ. FACTOR	.166E+05	G/CM**2-S	AF-FUEL PYROLYSIS FREQUENCY FACTOR	.299E+03	G/CM**2-S
EOX-OXIDIZER DECOMPOSITION ACTIV. ENERGY	21000.	CAL/MOLE	EF-FUEL PYROLYSIS ACTIVATION ENERGY	16900.	CAL/MOLE
AAP-OXIDIZER FLAME FREQUENCY FACTOR	2500000.	CM3-G/S-A	APF-PRIMARY FLAME FREQUENCY FACTOR	1400.	CM3-G/S-A
EAP-OXIDIZER FLAME ACTIVATION ENERGY	25000.	CAL/MOLE	EPF-PRIMARY FLAME ACTIVATION ENERGY	15000.	CAL/MOLE
DELAP-OXIDIZER FLAME REACTION ORDER	1.0		DELPF-PRIMARY FLAME REACTION ORDER	1.5	
PFMW-PRIMARY FLAME M.W. (1000 PSIA)	25.99	G/GMOLE	XNUPF-PRIMARY FLAME STOICHIOMETRY VARIABLE	9.30	
FFMW-FINAL FLAME M.W. (1000 PSIA)	26.95	G/GMOLE	XNUFF-FINAL FLAME STOICHIOMETRY VARIABLE	9.30	
CP-GAS PHASE SPECIFIC HEAT CAPACITY	.40	CAL/G-K	CIGN-IGNITION DELAY PROPORTIONALITY VALUE	190.	S-ATM/CM
XLAMB-GAS PHASE THERMAL CONDUCTIVITY	.50000E-05	CAL/CM-S-K	POWD-IGNITION DELAY DIAMETER EXPONENT	.800	
GAMMA-DIFFUSION COEFFICIENT PARAMETER	.760E-05	CM2-A/S-K	POWIG-IGNITION DELAY PRESSURE EXPONENT	.721	
PLAMB-SOLID PHASE THERMAL CONDUCTIVITY	.00030	CAL/CM-S-K	CS-SOLID PHASE SPECIFIC HEAT	.20	
FACTOR-FLAME TEMPERATURE PARAMETER	.50				
PSTART-STARTING PRESSURE (RATE/PRESSURE)	68.0272	ATMS	LIMBES-NUMBER OF TERMS (BURKE SCHUMANN)	40	
PSTOP-STOPPING PRESSURE (RATE/PRESSURE)	68.0272	ATMS	ERRBES-MINIMUM VALUE OF LAST TERM IN SERIES	.100E-06	
NPRESS-NUMBER OF PRESSURES CONSIDERED	1		ESTART-INITIAL N.D. DIFFUSION HEIGHT	.100E+00	
NDPM-NUMBER OF DIAMETERS/MODE-(RATE CAL.)	21		XHUHI-MAX VOLUME FRACTION (BURKE SCHUMANN)	.980	
NXDPM-NUMBER OF DIAMETERS/MODE-(C-CAL.)	201		XHULOW-MIN VOLUME FRACTION (BURKE SCHUMANN)	.300	
UINF-CROSS FLOW VELOCITY-EROSIVE BURNING	20000.	CM/SEC	CPRIME-CONSTANT IN PRANDTL MIXING LENGTH EXP.	.16	
YSTART-STARTING VALUE OF Y-COORDINATE(CM)	0.000000		COND-PROP. CONST.-DIFFUSION COEFFICIENT	1.00	
YSTOP-STOPPING VALUE OF Y-COORDINATE(CM)	1.000000		CONC-PROP. CONST.-THERMAL CONDUCTIVITY	1.00	
NSTEP-NUMBER OF STEPS-TURB. VEL. PROFILE	461		ITERO-NUMBER OF EROSIVE BURNING ITERATIONS	20	
INSTEP-STEPS/UNIT LN10(Y-COORDINATE)	100		NCYC-NUMBER OF LOG10 CYCLES USED	5	
PPERD-PRESSURE PERTURBATION (NONSTEADY)	.50	PERCENT	***** METAL PARAMETERS *****		
TPERD-TEMPERATURE PERTURBATION (NONSTEADY)	.50	PERCENT	ALTYPE-ALUMINUM TYPE	NONE	
BFAC-COHEN POSTULATE CONSTANT (MAGNITUDE)	1360.000	MICRON	BETA-MASS FRACTION OF METAL	0.0000	
FFAC-COHEN POSTULATE CONSTANT (FREQUENCY)	4.720		QM-LATENT HEAT OF METAL LIQUIFACTION	96.00	CAL/GRAM
OSTART-STARTING FREQUENCY (NONS. RESPONSE)	10.	HERTZ	RHOM-METAL DENSITY	2.710	G/CM**3
OSTOP-STOPPING FREQUENCY (NONS. RESPONSE)	100000.	HERTZ	DBARM-MEAN DIAMETER OF METAL DISTRIBUTION	6.000	MICRON
NOMEG-NUMBER OF FREQUENCIES CONSIDERED	81		SIGMAM-WIDTH PARAMETER OF METAL DISTRIBUTION	1.0000	
***** CATALYST PARAMETERS *****			***** ADDITIVE PARAMETERS *****		
CATYPE-CATALYST TYPE	NONE				
ALFCAT-MASS FRACTION OF CATALYST	0.0000		ADTYPE-ADDITIVE 1 TYPE	NONE	
SPSUR-SPECIFIC SURFACE OF CATALYST	0.0000	M**2/GRAM	ALFADD-ADDITIVE 1 MASS FRACTION	0.0000	
CAP-AP FLAME FACTOR (EXPONENTIAL)	0.00				
EAP2-AP FLAME FACTOR (ACT. ENERGY)	0.00	CAL/MOLE	ADTYPE-ADDITIVE 2 TYPE	NONE	
CPF-PF FLAME FACTOR (EXPONENTIAL)	14.96		ALFADD-ADDITIVE 2 MASS FRACTION	0.0000	
EPF2-PF FLAME FACTOR (ACT. ENERGY)	2610.00	CAL/MOLE			
XNUT-OXIDIZER VOLUME FRACTION	.77578		CX-VALUE OF C IN VF=C*DZERO**N EXPRESS.	.151E+00	
RHOT-TOTAL PROPELLANT DENSITY	1.71905	G/CM**3	XN-VALUE OF N IN VF=C*DZERO**N EXPRESS.	3.000	
RHOFA-FUEL-ALUMINUM MIXTURE DENSITY	.92000	G/CM**3	MODES-NUMBER OF OXIDIZER MODES	1	

MODE NUMBER	MEAN DIAMETER (DBARI)	MODE WIDTH PARAMETER (SIGMAI)	MASS FRACTION (ALFAI)	MASS FRACTION (CORR)
1	40.000	2.0000	.8800	

PRESSURE IS 1000.0 PSIA THE OXID/FUEL BEING CONSIDERED IS AP/ HTPB
INITIAL PROPELLANT TEMPERATURE IS 294.2 DEGREES KELVIN

DZERO (MICRONS)	BETAF	XSTPD (MICRONS)	XSTPF (MICRONS)	XSTAP (MICRONS)	XSTFD (MICRONS)	TF (K)	TS (K)	TSPF ...	TSFF (PERCENT)	TSAP ...	TSQL (K)	TSQF (K)	TSQM (K)	SOXP
3.04	1.000	1.033	.920	2.670	0.000	2998.3	1191.64	100.00	0.00	0.00	0.00	-295.23	0.00	2.829
3.94	1.000	1.384	.866	2.515	0.000	2998.3	1185.97	100.00	0.00	0.00	0.00	-295.23	0.00	2.780
5.09	.818	1.858	.798	2.318	.526	2998.3	1178.23	92.73	5.89	1.37	0.00	-295.23	0.00	2.718
6.59	.540	2.483	.704	2.044	2.845	2998.3	1166.05	81.77	11.92	6.31	0.00	-295.23	0.00	2.631
8.53	.360	3.350	.633	1.838	3.639	2998.3	1156.17	66.54	20.35	13.11	0.00	-295.23	0.00	2.557
11.03	.239	4.556	.573	1.662	4.760	2998.3	1147.04	51.82	26.87	21.31	0.00	-295.23	0.00	2.487
14.27	.158	6.245	.519	1.507	6.344	2998.3	1138.37	39.01	30.62	30.37	0.00	-295.23	0.00	2.418
18.47	.104	8.634	.471	1.367	8.587	2998.3	1130.00	28.52	31.63	39.85	0.00	-295.23	0.00	2.350
23.89	.068	12.045	.427	1.241	11.788	2998.3	1121.92	20.32	30.38	49.30	0.00	-295.23	0.00	2.282
30.92	.044	16.976	.389	1.128	16.402	2998.3	1114.25	14.13	27.54	58.33	0.00	-295.23	0.00	2.213
40.00	.028	24.207	.354	1.029	23.138	2998.3	1107.14	9.62	23.78	66.61	0.00	-295.23	0.00	2.145
51.75	.018	34.972	.325	.942	33.121	2998.3	1100.78	6.41	19.67	73.92	0.00	-295.23	0.00	2.077
66.96	.011	51.268	.299	.868	48.162	2998.3	1095.35	4.20	15.63	80.18	0.00	-295.23	0.00	2.007
86.64	.007	76.346	.278	.806	71.215	2998.3	1091.07	2.70	11.95	85.35	0.00	-295.23	0.00	1.934
112.10	.004	115.551	.260	.754	107.140	2998.3	1088.15	1.71	8.80	89.49	0.00	-295.23	0.00	1.858
145.05	.003	177.641	.245	.711	163.920	2998.3	1086.80	1.07	6.27	92.67	0.00	-295.23	0.00	1.773
187.67	.002	276.807	.233	.675	254.523	2998.3	1087.20	.66	4.34	95.01	0.00	-295.23	0.00	1.678
242.83	.001	435.578	.222	.644	399.598	2998.3	1089.53	.40	2.94	96.66	0.00	-295.23	0.00	1.568
314.18	.001	688.895	.212	.615	631.275	2998.3	1093.85	.24	1.97	97.79	0.00	-295.23	0.00	1.440
406.51	.000	1091.063	.202	.586	999.583	2998.3	1099.83	.15	1.32	98.54	0.00	-295.23	0.00	1.303
525.97	.000	1737.133	.193	.561	1591.777	2998.3	1105.73	.09	.87	99.04	0.00	-295.23	0.00	1.183

DZERO (MICRONS)	RATE (CM/SEC)	XNUV	ALFAV	RHOV (G/CM**3)	FSKP	XLAMAP (CAL/CM-S-K)	XLAMPF (CAL/CM-S-K)	XLAMFF (CAL/CM-S-K)
3.04	3.3883	.7758	.8800	1.7190	.0005	.1801E-03	.2289E-03	.2289E-03
3.94	3.1912	.7758	.8800	1.7190	.0019	.1799E-03	.2287E-03	.2287E-03
5.09	2.9420	.7758	.8800	1.7190	.0061	.1797E-03	.2285E-03	.2285E-03
6.59	2.5937	.7758	.8800	1.7190	.0172	.1792E-03	.2282E-03	.2282E-03
8.53	2.3330	.7758	.8800	1.7190	.0421	.1789E-03	.2279E-03	.2279E-03
11.03	2.1096	.7758	.8800	1.7190	.0901	.1786E-03	.2276E-03	.2276E-03
14.27	1.9123	.7758	.8800	1.7190	.1677	.1783E-03	.2274E-03	.2274E-03
18.47	1.7347	.7758	.8800	1.7190	.2720	.1780E-03	.2272E-03	.2272E-03
23.89	1.5747	.7758	.8800	1.7190	.3842	.1777E-03	.2269E-03	.2269E-03
30.92	1.4316	.7758	.8800	1.7190	.4727	.1774E-03	.2267E-03	.2267E-03
40.00	1.3055	.7758	.8800	1.7190	.5065	.1772E-03	.2265E-03	.2265E-03
51.75	1.1959	.7758	.8800	1.7190	.4727	.1769E-03	.2264E-03	.2264E-03
66.96	1.1020	.7758	.8800	1.7190	.3842	.1768E-03	.2262E-03	.2262E-03
86.64	1.0229	.7758	.8800	1.7190	.2720	.1766E-03	.2261E-03	.2261E-03
112.10	.9570	.7758	.8800	1.7190	.1677	.1765E-03	.2260E-03	.2260E-03
145.05	.9026	.7758	.8800	1.7190	.0901	.1765E-03	.2260E-03	.2260E-03
187.67	.8572	.7758	.8800	1.7190	.0421	.1765E-03	.2260E-03	.2260E-03
242.83	.8176	.7758	.8800	1.7190	.0172	.1765E-03	.2260E-03	.2260E-03
314.18	.7805	.7758	.8800	1.7190	.0061	.1767E-03	.2262E-03	.2262E-03
406.51	.7441	.7758	.8800	1.7190	.0019	.1769E-03	.2263E-03	.2263E-03
525.97	.7115	.7758	.8800	1.7190	.0005	.1771E-03	.2265E-03	.2265E-03

MODE NUMBER 1 SERIES RATE = 1.3638 CM/SEC PARALLEL RATE = 1.2926 CM/SEC BETAR = .3591

THE CONVERGENCE ON THE EROSIVE BURNING RATE FOLLOWS

1 1 1.87237 1.36384 BOUNDARY LAYER THICKNESS = 3400.00 MICRONS
TAVBL = 2054.0 XMEW = .90643E-03 GRAMS/CM-SEC AMWBL = 26.4695

***** EROSIVE BURNING OUTPUT *****

FREE STREAM VELOCITY	20000.0 CM/SEC	FREE STREAM GAS PRESSURE	68.027 ATMS
BOUND.LAYER TEMPERATURE	2054.0 KELVIN	BOUND.LAYER GAS DENSITY	.10684E-01 GRAMS/CM**3
MOLECULAR VISCOSITY	.90643E-03 GRAMS/CM-S	PIPE HYDRAULIC DIAM.	2.00 CM
REYNOLDS NUMBER	.47146E+06	BLOWING PARAMETER, B	.43815E+01
COEFFICIENT OF FRICTION (B=0)	.50086E-02	WALL SHEAR STRESS	.59389E+03 DYNE/CM**2
COEFFICIENT OF FRICTION	.27794E-03	INITIAL PROPELLANT TEMP	294.15 KELVIN
AVERAGE ROUGHNESS HEIGHT	.001895 CM	CF/CFZERO EXPRESSION (IBLOW)	4

DZERO (MIC)	ROUGH (MIC)	XSTPD (MIC)	XSTPF (MIC)	XSTAP (MIC)	XSTFD (MIC)	XLAMAP ...	XLAMPF (CAL/CM-S-K)	XLAMFF ...	GAMAPF (CM2/S)	GAMAFF (CM2/S)
3.042	1.467	1.0343	.9306	2.7023	0.0000	.188E-03	.234E-03	.239E-03	.729E-01	.790E-01
3.936	1.878	1.3859	.8809	2.5579	0.0000	.187E-03	.236E-03	.238E-03	.731E-01	-I
5.093	2.395	1.8594	.8161	2.3698	.4040	.186E-03	.236E-03	.239E-03	.735E-01	.919E-01
6.589	3.039	2.4827	.7298	2.1192	2.7440	.184E-03	.234E-03	.263E-03	.744E-01	.101E+00
8.525	3.865	3.3361	.6682	1.9403	3.4795	.183E-03	.233E-03	.271E-03	.766E-01	.103E+00
11.031	4.921	4.4905	.6201	1.8007	4.4915	.182E-03	.232E-03	.284E-03	.806E-01	.108E+00
14.272	6.270	6.0343	.5825	1.6914	5.8652	.181E-03	.231E-03	.305E-03	.875E-01	.117E+00
18.467	7.989	8.0773	.5531	1.6061	7.7094	.181E-03	.231E-03	.335E-03	.980E-01	.129E+00
23.893	10.173	10.7646	.5302	1.5397	10.1624	.181E-03	.230E-03	.378E-03	.113E+00	.146E+00
30.915	12.934	14.2751	.5126	1.4885	13.3978	.180E-03	.230E-03	.437E-03	.133E+00	.169E+00
40.000	16.400	18.8626	.4984	1.4471	17.6548	.180E-03	.230E-03	.515E-03	.159E+00	.199E+00
51.755	20.704	24.8503	.4864	1.4124	23.2370	.180E-03	.230E-03	.616E-03	.193E+00	.238E+00
66.964	25.963	32.6532	.4760	1.3822	30.5346	.180E-03	.230E-03	.745E-03	.237E+00	.288E+00
86.643	32.225	42.7964	.4664	1.3542	40.0553	.180E-03	.230E-03	.911E-03	.292E+00	.351E+00
112.104	39.332	55.9563	.4569	1.3269	52.4453	.180E-03	.230E-03	.112E-02	.363E+00	.432E+00
145.048	46.589	72.9741	.4471	1.2982	68.5246	.181E-03	.230E-03	.139E-02	.453E+00	.533E+00
187.674	51.862	94.8757	.4360	1.2660	89.3125	.181E-03	.230E-03	.173E-02	.568E+00	.660E+00
242.825	49.882	122.9562	.4234	1.2294	116.1171	.182E-03	.231E-03	.216E-02	.715E+00	.820E+00
314.184	37.235	159.5762	.4145	1.2037	151.0111	.182E-03	.231E-03	.272E-02	.903E+00	.103E+01
406.513	67.232	208.3117	.4121	1.1965	197.1407	.182E-03	.231E-03	.343E-02	.114E+01	.129E+01
525.975	111.152	272.2695	.4117	1.1954	257.5804	.181E-03	.231E-03	.434E-02	.144E+01	.164E+01

DZERO (MIC)	R-EROS (CM/S)	R-NEROS (CM/S)	EBETA	BETAF	TS (K)	TSB (K)	TSPF ...	TSFF (PERCENT)	TSAP ...	TSBN (K)
3.042	3.4291	3.3883	.0120	1.0000	1192.89	1192.89	100.00	0.00	0.00	-122.56
3.936	3.2459	3.1912	.0172	1.0000	1187.76	1187.76	100.00	0.00	0.00	-121.86
5.093	3.0072	2.9420	.0222	.8356	1180.51	1180.51	93.17	5.63	1.20	-120.87
6.589	2.6892	2.5937	.0368	.5596	1169.77	1169.77	80.57	13.98	5.45	-119.40
8.525	2.4622	2.3330	.0554	.3813	1161.67	1161.67	65.16	24.01	10.83	-118.30
11.031	2.2850	2.1096	.0831	.2629	1155.14	1155.14	50.99	32.39	16.62	-117.41
14.272	2.1464	1.9123	.1224	.1838	1150.06	1150.06	39.17	38.65	22.18	-116.71
18.467	2.0381	1.7347	.1749	.1304	1146.31	1146.31	29.81	43.05	27.14	-116.20
23.893	1.9538	1.5747	.2407	.0938	1143.84	1143.84	22.60	46.06	31.35	-115.87
30.915	1.8889	1.4316	.3194	.0684	1142.62	1142.62	17.12	48.13	34.76	-115.70
40.000	1.8364	1.3055	.4066	.0503	1142.51	1142.51	12.97	49.48	37.55	-115.69
51.755	1.7924	1.1959	.4987	.0373	1143.52	1143.52	9.83	50.31	39.86	-115.82
66.964	1.7540	1.1020	.5916	.0278	1145.79	1145.79	7.46	50.77	41.78	-116.13

86.643	1.7185	1.0229	.6800	.0207	1149.60	1149.60	5.66	50.94	43.41	-116.65
112.104	1.6838	.9570	.7594	.0155	1155.50	1155.50	4.29	50.90	44.81	-117.46
145.048	1.6474	.9026	.8251	.0117	1164.51	1164.51	3.25	50.73	46.02	-118.69
187.674	1.6065	.8572	.8741	.0087	1178.26	1178.26	2.45	50.49	47.06	-120.56
242.825	1.5601	.8176	.9081	.0066	1196.85	1196.85	1.84	50.23	47.93	-123.09
314.184	1.5275	.7805	.9570	.0049	1207.41	1207.41	1.39	49.92	48.68	-124.54
406.513	1.5184	.7441	1.0407	.0038	1201.75	1201.75	1.07	49.37	49.56	-123.76
525.975	1.5169	.7115	1.1319	.0029	1191.50	1191.50	.83	48.74	50.43	-122.37

1 2 1.81979 1.61811 BOUNDARY LAYER THICKNESS = 2900.00 MICRONS
TAVBL = 2072.7 XMEW = .91054E-03 GRAMS/CM-SEC AMWBL = 26.4695

***** EROSIVE BURNING OUTPUT *****

FREE STREAM VELOCITY	20000.0 CM/SEC	FREE STREAM GAS PRESSURE	68.027 ATMS
BOUND.LAYER TEMPERATURE	2072.7 KELVIN	BOUND.LAYER GAS DENSITY	.10587E-01 GRAMS/CM**3
MOLECULAR VISCOSITY	.91054E-03 GRAMS/CM-S	PIPE HYDRAULIC DIAM.	2.00 CM
REYNOLDS NUMBER	.46510E+06	BLOWING PARAMETER, B	.52388E+01
COEFFICIENT OF FRICTION (B=0)	.50150E-02	WALL SHEAR STRESS	.29679E+03 DYNE/CM**2
COEFFICIENT OF FRICTION	.14016E-03	INITIAL PROPELLANT TEMP	294.15 KELVIN
AVERAGE ROUGHNESS HEIGHT	.001903 CM	CF/CFZERO EXPRESSION (IBLOW)	4

DZERO (MIC)	ROUGH (MIC)	XSTPD (MIC)	XSTPF (MIC)	XSTAP (MIC)	XSTFD (MIC)	XLAMAP ...	XLAMPF (CAL/CM-S-K)	XLAMFF ...	GAMAPF (CM2/S)	GAMAFF (CM2/S)
3.042	1.466	1.0338	.9255	2.6873	0.0000	.185E-03	.232E-03	.234E-03	.727E-01	.790E-01
3.936	1.876	1.3851	.8742	2.5383	0.0000	.184E-03	.232E-03	.234E-03	.727E-01	-I
5.093	2.392	1.8590	.8082	2.3469	.4547	.183E-03	.233E-03	.235E-03	.728E-01	.868E-01
6.589	3.033	2.4842	.7200	2.0907	2.7716	.182E-03	.231E-03	.251E-03	.732E-01	.931E-01
8.525	3.856	3.3449	.6566	1.9065	3.5205	.181E-03	.230E-03	.257E-03	.745E-01	.953E-01
11.031	4.907	4.5174	.6065	1.7611	4.5529	.180E-03	.230E-03	.268E-03	.774E-01	.996E-01
14.272	6.249	6.0933	.5674	1.6475	5.9567	.180E-03	.229E-03	.287E-03	.829E-01	.107E+00
18.467	7.960	8.1801	.5372	1.5599	7.8422	.180E-03	.229E-03	.314E-03	.921E-01	.118E+00
23.893	10.136	10.9189	.5142	1.4931	10.3485	.179E-03	.229E-03	.354E-03	.106E+00	.133E+00
30.915	12.891	14.4952	.4968	1.4426	13.6517	.179E-03	.229E-03	.409E-03	.124E+00	.155E+00
40.000	16.352	19.1561	.4832	1.4030	17.9902	.179E-03	.229E-03	.482E-03	.149E+00	.183E+00
51.755	20.657	25.2327	.4722	1.3711	23.6663	.179E-03	.229E-03	.578E-03	.181E+00	.221E+00
66.964	25.927	33.1385	.4627	1.3435	31.0805	.179E-03	.229E-03	.703E-03	.223E+00	.268E+00
86.643	32.219	43.4103	.4541	1.3185	40.7371	.179E-03	.229E-03	.862E-03	.276E+00	.329E+00
112.104	39.396	56.7241	.4456	1.2940	53.2933	.180E-03	.229E-03	.107E-02	.344E+00	.406E+00
145.048	46.816	73.9301	.4368	1.2682	69.5718	.180E-03	.229E-03	.133E-02	.431E+00	.503E+00
187.674	52.484	96.0636	.4266	1.2388	90.6000	.180E-03	.229E-03	.166E-02	.542E+00	.626E+00
242.825	51.323	124.4360	.4150	1.2050	117.6675	.181E-03	.230E-03	.207E-02	.684E+00	.780E+00
314.184	39.211	161.3033	.4062	1.1796	152.8878	.181E-03	.230E-03	.261E-02	.865E+00	.978E+00
406.513	65.243	210.3605	.4040	1.1732	199.3861	.181E-03	.230E-03	.330E-02	.109E+01	.124E+01
525.975	111.152	274.9166	.4044	1.1744	260.4293	.181E-03	.230E-03	.419E-02	.139E+01	.157E+01

DZERO (MIC)	R-EROS (CM/S)	R-NEROS (CM/S)	EBETA	BETAF	TS (K)	TSB (K)	TSPF ...	TSFF (PERCENT)	TSAP ...	TSBN (K)
3.042	3.4102	3.3883	.0065	1.0000	1192.31	1192.31	100.00	0.00	0.00	-122.48
3.936	3.2211	3.1912	.0094	1.0000	1186.95	1186.95	100.00	0.00	0.00	-121.75
5.093	2.9781	2.9420	.0123	.8277	1179.50	1179.50	92.94	5.79	1.28	-120.73
6.589	2.6530	2.5937	.0229	.5518	1168.37	1168.37	80.79	13.47	5.74	-119.21
8.525	2.4193	2.3330	.0370	.3737	1159.87	1159.87	65.38	23.12	11.49	-118.05
11.031	2.2349	2.1096	.0594	.2556	1152.88	1152.88	51.05	31.18	17.78	-117.10

14.272	2.0907	1.9123	.0933	.1773	1147.38	1147.38	39.04	37.12	23.84	-116.35
18.467	1.9795	1.7347	.1411	.1250	1143.32	1143.32	29.59	41.23	29.19	-115.80
23.893	1.8947	1.5747	.2032	.0897	1140.66	1140.66	22.35	44.01	33.63	-115.43
30.915	1.8306	1.4316	.2787	.0652	1139.33	1139.33	16.89	45.94	37.17	-115.25
40.000	1.7804	1.3055	.3638	.0480	1139.18	1139.18	12.78	47.24	39.98	-115.23
51.755	1.7399	1.1959	.4549	.0356	1140.22	1140.22	9.68	48.11	42.21	-115.37
66.964	1.7049	1.1020	.5471	.0266	1142.49	1142.49	7.34	48.63	44.03	-115.68
86.643	1.6732	1.0229	.6357	.0199	1146.30	1146.30	5.57	48.90	45.53	-116.20
112.104	1.6420	.9570	.7158	.0150	1152.11	1152.11	4.22	48.98	46.80	-117.00
145.048	1.6093	.9026	.7829	.0112	1160.90	1160.90	3.20	48.92	47.88	-118.19
187.674	1.5721	.8572	.8340	.0085	1174.22	1174.22	2.41	48.81	48.78	-120.01
242.825	1.5291	.8176	.8703	.0063	1192.57	1192.57	1.81	48.68	49.50	-122.51
314.184	1.4968	.7805	.9177	.0048	1204.33	1204.33	1.37	48.46	50.16	-124.12
406.513	1.4888	.7441	1.0009	.0037	1199.84	1199.84	1.06	48.02	50.92	-123.50
525.975	1.4902	.7115	1.0944	.0028	1189.12	1189.12	.82	47.46	51.72	-122.04

1 3 1.79548 1.78522 BOUNDARY LAYER THICKNESS = 2600.00 MICRONS
TAVBL = 2071.1 XMEW = .91019E-03 GRAMS/CM-SEC AMWBL = 26.4695

***** EROSIVE BURNING OUTPUT *****

FREE STREAM VELOCITY	20000.0 CM/SEC	FREE STREAM GAS PRESSURE	68.027 ATMS
BOUND.LAYER TEMPERATURE	2071.1 KELVIN	BOUND.LAYER GAS DENSITY	.10596E-01 GRAMS/CM**3
MOLECULAR VISCOSITY	.91019E-03 GRAMS/CM-S	PIPE HYDRAULIC DIAM.	2.00 CM
REYNOLDS NUMBER	.46564E+06	BLOWING PARAMETER, B	.57760E+01
COEFFICIENT OF FRICTION (B=0)	.50145E-02	WALL SHEAR STRESS	.19092E+03 DYNE/CM**2
COEFFICIENT OF FRICTION	.90096E-04	INITIAL PROPELLANT TEMP	294.15 KELVIN
AVERAGE ROUGHNESS HEIGHT	.001902 CM	CF/CFZERO EXPRESSION (IBLOW)	4

DZERO (MIC)	ROUGH (MIC)	XSTPD (MIC)	XSTPF (MIC)	XSTAP (MIC)	XSTFD (MIC)	XLAMAP ...	XLAMPF (CAL/CM-S-K)	XLAMFF ...	GAMAPF (CM2/S)	GAMAFF (CM2/S)
3.042	1.466	1.0336	.9236	2.6818	0.0000	.183E-03	.231E-03	.233E-03	.726E-01	.790E-01
3.936	1.875	1.3848	.8716	2.5310	0.0000	.183E-03	.231E-03	.232E-03	.726E-01	-I
5.093	2.391	1.8588	.8052	2.3380	.4758	.182E-03	.231E-03	.233E-03	.726E-01	.847E-01
6.589	3.031	2.4845	.7159	2.0788	2.7856	.181E-03	.230E-03	.246E-03	.728E-01	.898E-01
8.525	3.852	3.3483	.6514	1.8916	3.5414	.180E-03	.230E-03	.251E-03	.737E-01	.918E-01
11.031	4.900	4.5296	.6002	1.7429	4.5844	.180E-03	.229E-03	.261E-03	.760E-01	.957E-01
14.272	6.239	6.1231	.5602	1.6267	6.0041	.179E-03	.229E-03	.278E-03	.808E-01	.102E+00
18.467	7.946	8.2343	.5296	1.5377	7.9111	.179E-03	.228E-03	.304E-03	.892E-01	.113E+00
23.893	10.118	11.0007	.5065	1.4708	10.4448	.179E-03	.228E-03	.342E-03	.102E+00	.128E+00
30.915	12.869	14.6096	.4893	1.4208	13.7821	.179E-03	.228E-03	.395E-03	.120E+00	.149E+00
40.000	16.329	19.3071	.4761	1.3826	18.1583	.179E-03	.228E-03	.467E-03	.144E+00	.176E+00
51.755	20.634	25.4234	.4657	1.3522	23.8790	.179E-03	.228E-03	.561E-03	.176E+00	.213E+00
66.964	25.909	33.3762	.4567	1.3263	31.3429	.179E-03	.228E-03	.684E-03	.217E+00	.259E+00
86.643	32.214	43.7008	.4487	1.3028	41.0593	.179E-03	.228E-03	.840E-03	.269E+00	.319E+00
112.104	39.422	57.0790	.4408	1.2799	53.6829	.179E-03	.228E-03	.104E-02	.336E+00	.395E+00
145.048	46.909	74.3614	.4324	1.2555	70.0425	.179E-03	.229E-03	.130E-02	.422E+00	.491E+00
187.674	52.733	96.5854	.4228	1.2276	91.1647	.180E-03	.229E-03	.162E-02	.531E+00	.612E+00
242.825	51.894	125.0687	.4116	1.1952	118.3284	.181E-03	.229E-03	.204E-02	.671E+00	.765E+00
314.184	40.006	162.0305	.4029	1.1700	153.6693	.181E-03	.230E-03	.257E-02	.850E+00	.960E+00
406.513	64.447	211.2009	.4009	1.1641	200.3083	.181E-03	.230E-03	.325E-02	.108E+01	.122E+01
525.975	111.152	275.9503	.4017	1.1664	261.5566	.180E-03	.229E-03	.413E-02	.137E+01	.155E+01

DZERO (MIC)	R-EROS (CM/S)	R-NEROS (CM/S)	EBETA	BETAF	TS (K)	TSB (K)	TSPF ...	TSFF (PERCENT)	TSAP ...	TSBN (K)

3.042	3.4032	3.3883	.0044	1.0000	1192.10	1192.10	100.00	0.00	0.00	-122.45
3.936	3.2118	3.1912	.0064	1.0000	1186.65	1186.65	100.00	0.00	0.00	-121.70
5.093	2.9668	2.9420	.0085	.8246	1179.10	1179.10	92.86	5.83	1.31	-120.68
6.589	2.6380	2.5937	.0171	.5486	1167.79	1167.79	80.94	13.19	5.87	-119.13
8.525	2.4004	2.3330	.0289	.3704	1159.07	1159.07	65.54	22.65	11.81	-117.94
11.031	2.2117	2.1096	.0484	.2523	1151.82	1151.82	51.10	30.54	18.36	-116.96
14.272	2.0642	1.9123	.0795	.1742	1146.08	1146.08	38.99	36.32	24.69	-116.17
18.467	1.9513	1.7347	.1248	.1224	1141.86	1141.86	29.47	40.28	30.25	-115.60
23.893	1.8664	1.5747	.1852	.0877	1139.11	1139.11	22.22	42.97	34.81	-115.22
30.915	1.8030	1.4316	.2594	.0638	1137.74	1137.74	16.77	44.84	38.39	-115.03
40.000	1.7545	1.3055	.3439	.0469	1137.61	1137.61	12.68	46.15	41.17	-115.02
51.755	1.7159	1.1959	.4348	.0349	1138.68	1138.68	9.60	47.05	43.35	-115.16
66.964	1.6830	1.1020	.5272	.0261	1141.00	1141.00	7.28	47.63	45.09	-115.48
86.643	1.6532	1.0229	.6162	.0195	1144.83	1144.83	5.52	47.97	46.51	-116.00
112.104	1.6241	.9570	.6970	.0147	1150.65	1150.65	4.19	48.12	47.69	-116.80
145.048	1.5933	.9026	.7651	.0111	1159.37	1159.37	3.17	48.13	48.69	-117.98
187.674	1.5578	.8572	.8174	.0083	1172.56	1172.56	2.40	48.08	49.52	-119.78
242.825	1.5166	.8176	.8550	.0063	1190.83	1190.83	1.80	48.04	50.16	-122.28
314.184	1.4847	.7805	.9022	.0047	1203.07	1203.07	1.37	47.87	50.76	-123.94
406.513	1.4772	.7441	.9854	.0036	1199.08	1199.08	1.05	47.49	51.46	-123.40
525.975	1.4801	.7115	1.0802	.0028	1188.22	1188.22	.81	46.97	52.22	-121.92

1 4 1.78451 1.79418 BOUNDARY LAYER THICKNESS = 2600.00 MICRONS
TAVBL = 2070.4 XMEW = .91002E-03 GRAMS/CM-SEC AMWBL = 26.4695

***** EROSIVE BURNING OUTPUT *****

FREE STREAM VELOCITY	20000.0 CM/SEC	FREE STREAM GAS PRESSURE	68.027 ATMS
BOUND.LAYER TEMPERATURE	2070.4 KELVIN	BOUND.LAYER GAS DENSITY	.10599E-01 GRAMS/CM**3
MOLECULAR VISCOSITY	.91002E-03 GRAMS/CM-S	PIPE HYDRAULIC DIAM.	2.00 CM
REYNOLDS NUMBER	.46589E+06	BLOWING PARAMETER, B	.58033E+01
COEFFICIENT OF FRICTION (B=0)	.50141E-02	WALL SHEAR STRESS	.18670E+03 DYNE/CM**2
COEFFICIENT OF FRICTION	.88070E-04	INITIAL PROPELLANT TEMP	294.15 KELVIN
AVERAGE ROUGHNESS HEIGHT	.001902 CM	CF/CFZERO EXPRESSION (IBLOW)	4

DZERO (MIC)	ROUGH (MIC)	XSTPD (MIC)	XSTPF (MIC)	XSTAP (MIC)	XSTFD (MIC)	XLAMAP ...	XLAMPF (CAL/CM-S-K)	XLAMFF ...	GAMAPF (CM2/S)	GAMAFF (CM2/S)
3.042	1.466	1.0336	.9235	2.6816	0.0000	.183E-03	.231E-03	.233E-03	.726E-01	.790E-01
3.936	1.875	1.3848	.8715	2.5307	0.0000	.183E-03	.231E-03	.232E-03	.726E-01	-I
5.093	2.391	1.8588	.8050	2.3377	.4765	.182E-03	.231E-03	.233E-03	.726E-01	.846E-01
6.589	3.031	2.4845	.7157	2.0783	2.7862	.181E-03	.230E-03	.246E-03	.728E-01	.897E-01
8.525	3.852	3.3484	.6512	1.8910	3.5423	.180E-03	.230E-03	.251E-03	.736E-01	.917E-01
11.031	4.900	4.5301	.6000	1.7421	4.5858	.180E-03	.229E-03	.261E-03	.759E-01	.955E-01
14.272	6.238	6.1244	.5599	1.6258	6.0062	.179E-03	.229E-03	.277E-03	.807E-01	.102E+00
18.467	7.945	8.2366	.5292	1.5368	7.9141	.179E-03	.228E-03	.303E-03	.891E-01	.113E+00
23.893	10.117	11.0043	.5062	1.4698	10.4489	.179E-03	.228E-03	.342E-03	.102E+00	.128E+00
30.915	12.869	14.6144	.4890	1.4199	13.7875	.179E-03	.228E-03	.395E-03	.120E+00	.148E+00
40.000	16.328	19.3133	.4759	1.3818	18.1651	.179E-03	.228E-03	.467E-03	.144E+00	.176E+00
51.755	20.633	25.4309	.4654	1.3514	23.8874	.179E-03	.228E-03	.561E-03	.176E+00	.212E+00
66.964	25.908	33.3853	.4565	1.3256	31.3530	.179E-03	.228E-03	.683E-03	.217E+00	.259E+00
86.643	32.214	43.7116	.4485	1.3022	41.0712	.179E-03	.228E-03	.840E-03	.269E+00	.319E+00
112.104	39.423	57.0917	.4406	1.2794	53.6968	.179E-03	.228E-03	.104E-02	.336E+00	.394E+00
145.048	46.912	74.3762	.4322	1.2551	70.0587	.179E-03	.229E-03	.130E-02	.421E+00	.490E+00
187.674	52.741	96.6023	.4226	1.2272	91.1833	.180E-03	.229E-03	.162E-02	.531E+00	.612E+00

242.825	51.912	125.0883	.4115	1.1949	118.3491	.181E-03	.229E-03	.204E-02	.671E+00	.764E+00
314.184	40.030	162.0518	.4028	1.1697	153.6924	.181E-03	.230E-03	.257E-02	.850E+00	.959E+00
406.513	64.425	211.2237	.4008	1.1639	200.3338	.181E-03	.230E-03	.325E-02	.108E+01	.122E+01
525.975	111.152	275.9760	.4016	1.1662	261.5853	.180E-03	.229E-03	.413E-02	.137E+01	.154E+01

DZERO (MIC)	R-EROS (CM/S)	R-NEROS (CM/S)	EBETA	BETAF	TS (K)	TSB (K)	TSPF ...	TSFF (PERCENT)	TSAP ...	TSBN (K)
3.042	3.4029	3.3883	.0043	1.0000	1192.09	1192.09	100.00	0.00	0.00	-122.45
3.936	3.2114	3.1912	.0063	1.0000	1186.64	1186.64	100.00	0.00	0.00	-121.70
5.093	2.9665	2.9420	.0083	.8245	1179.09	1179.09	92.86	5.84	1.31	-120.67
6.589	2.6374	2.5937	.0168	.5484	1167.76	1167.76	80.95	13.18	5.87	-119.13
8.525	2.3996	2.3330	.0285	.3703	1159.04	1159.04	65.54	22.63	11.82	-117.94
11.031	2.2107	2.1096	.0480	.2521	1151.78	1151.78	51.10	30.51	18.39	-116.95
14.272	2.0631	1.9123	.0789	.1740	1146.03	1146.03	38.99	36.29	24.73	-116.16
18.467	1.9501	1.7347	.1242	.1223	1141.80	1141.80	29.46	40.24	30.29	-115.59
23.893	1.8652	1.5747	.1845	.0876	1139.04	1139.04	22.22	42.93	34.86	-115.21
30.915	1.8018	1.4316	.2586	.0637	1137.67	1137.67	16.77	44.79	38.44	-115.03
40.000	1.7535	1.3055	.3431	.0469	1137.55	1137.55	12.68	46.10	41.22	-115.01
51.755	1.7149	1.1959	.4340	.0348	1138.62	1138.62	9.60	47.01	43.39	-115.16
66.964	1.6822	1.1020	.5264	.0260	1140.95	1140.95	7.28	47.59	45.13	-115.47
86.643	1.6525	1.0229	.6155	.0195	1144.77	1144.77	5.52	47.93	46.55	-115.99
112.104	1.6235	.9570	.6964	.0147	1150.59	1150.59	4.19	48.09	47.73	-116.79
145.048	1.5927	.9026	.7645	.0111	1159.32	1159.32	3.17	48.11	48.72	-117.98
187.674	1.5573	.8572	.8168	.0083	1172.50	1172.50	2.40	48.06	49.54	-119.78
242.825	1.5163	.8176	.8546	.0063	1190.78	1190.78	1.80	48.02	50.18	-122.27
314.184	1.4844	.7805	.9017	.0047	1203.03	1203.03	1.37	47.85	50.78	-123.94
406.513	1.4769	.7441	.9849	.0036	1199.05	1199.05	1.05	47.47	51.48	-123.40
525.975	1.4753	.7115	1.0798	.0028	1188.19	1188.19	.81	46.96	52.23	-121.91

1 5 1.79448 1.79448 BOUNDARY LAYER THICKNESS = 2600.00 MICRONS
TAUBL = 2070.3 XMEW = .91002E-03 GRAMS/CM-SEC AMWBL = 26.4695

***** EROSIVE BURNING OUTPUT *****

FREE STREAM VELOCITY	20000.0 CM/SEC	FREE STREAM GAS PRESSURE	68.027 ATMS
BOUND.LAYER TEMPERATURE	2070.3 KELVIN	BOUND.LAYER GAS DENSITY	.10599E-01 GRAMS/CM**3
MOLECULAR VISCOSITY	.91002E-03 GRAMS/CM-S	PIPE HYDRAULIC DIAM.	2.00 CM
REYNOLDS NUMBER	.46590E+06	BLOWING PARAMETER, B	.58043E+01
COEFFICIENT OF FRICTION (B=0)	.50141E-02	WALL SHEAR STRESS	.18655E+03 DYNE/CM**2
COEFFICIENT OF FRICTION	.88002E-04	INITIAL PROPELLANT TEMP	294.15 KELVIN
AVERAGE ROUGHNESS HEIGHT	.001902 CM	CF/CFZERO EXPRESSION (IBLOW)	4

DZERO (MIC)	ROUGH (MIC)	XSTPD (MIC)	XSTPF (MIC)	XSTAP (MIC)	XSTFD (MIC)	XLAMAP ...	XLAMPF (CAL/CM-S-K)	XLAMFF ...	GAMAPF (CM2/S)	GAMAFF (CM2/S)
3.042	1.466	1.0336	.9235	2.6816	0.0000	.183E-03	.231E-03	.233E-03	.726E-01	.790E-01
3.936	1.875	1.3848	.8715	2.5307	0.0000	.183E-03	.231E-03	.232E-03	.726E-01	-I
5.093	2.391	1.8588	.8050	2.3377	.4766	.182E-03	.231E-03	.233E-03	.726E-01	.846E-01
6.589	3.031	2.4845	.7157	2.0783	2.7862	.181E-03	.230E-03	.246E-03	.728E-01	.897E-01
8.525	3.852	3.3484	.6512	1.8909	3.5423	.180E-03	.230E-03	.251E-03	.736E-01	.916E-01
11.031	4.900	4.5301	.6000	1.7421	4.5858	.180E-03	.229E-03	.261E-03	.759E-01	.955E-01
14.272	6.238	6.1244	.5599	1.6258	6.0062	.179E-03	.229E-03	.277E-03	.807E-01	.102E+00
18.467	7.945	8.2367	.5292	1.5367	7.9142	.179E-03	.228E-03	.303E-03	.891E-01	.113E+00
23.893	10.117	11.0044	.5062	1.4698	10.4490	.179E-03	.228E-03	.341E-03	.102E+00	.128E+00
30.915	12.869	14.6145	.4890	1.4199	13.7877	.179E-03	.228E-03	.395E-03	.120E+00	.148E+00

40.000	16.328	19.3135	.4759	1.3818	18.1654	.179E-03	.228E-03	.467E-03	.144E+00	.176E+00
51.755	20.633	25.4312	.4654	1.3514	23.8877	.179E-03	.228E-03	.561E-03	.176E+00	.212E+00
66.964	25.908	33.3856	.4565	1.3256	31.3534	.179E-03	.228E-03	.683E-03	.217E+00	.259E+00
86.643	32.214	43.7120	.4485	1.3022	41.0716	.179E-03	.228E-03	.840E-03	.269E+00	.319E+00
112.104	39.423	57.0921	.4406	1.2793	53.6973	.179E-03	.228E-03	.104E-02	.336E+00	.394E+00
145.048	46.912	74.3765	.4322	1.2551	70.0593	.179E-03	.229E-03	.130E-02	.421E+00	.490E+00
187.674	52.741	96.6029	.4226	1.2272	91.1838	.180E-03	.229E-03	.162E-02	.531E+00	.611E+00
242.825	51.913	125.0889	.4115	1.1949	118.3498	.181E-03	.229E-03	.204E-02	.671E+00	.764E+00
314.184	40.031	162.0525	.4028	1.1697	153.6931	.181E-03	.230E-03	.257E-02	.850E+00	.959E+00
406.513	64.424	211.2244	.4008	1.1639	200.3346	.181E-03	.230E-03	.325E-02	.108E+01	.122E+01
525.975	111.152	275.9767	.4016	1.1662	261.5861	.180E-03	.229E-03	.413E-02	.137E+01	.154E+01

DZERO (MIC)	R-EROS (CM/S)	R-NEROS (CM/S)	EBETA	BETAF	TS (K)	TSB (K)	TSPF ...	TSFF (PERCENT)	TSAP ...	TSBN (K)
3.042	3.4029	3.3883	.0043	1.0000	1192.09	1192.09	100.00	0.00	0.00	-122.45
3.936	3.2114	3.1912	.0063	1.0000	1186.63	1186.63	100.00	0.00	0.00	-121.70
5.093	2.9664	2.9420	.0083	.8245	1179.09	1179.09	92.86	5.84	1.31	-120.67
6.589	2.6373	2.5937	.0168	.5484	1167.76	1167.76	80.95	13.18	5.87	-119.13
8.525	2.3996	2.3330	.0285	.3702	1159.03	1159.03	65.54	22.63	11.82	-117.94
11.031	2.2107	2.1096	.0479	.2521	1151.78	1151.78	51.10	30.51	18.39	-116.95
14.272	2.0630	1.9123	.0789	.1740	1146.02	1146.02	38.99	36.28	24.73	-116.16
18.467	1.9501	1.7347	.1241	.1223	1141.79	1141.79	29.46	40.24	30.29	-115.59
23.893	1.8652	1.5747	.1845	.0876	1139.04	1139.04	22.22	42.93	34.86	-115.21
30.915	1.8018	1.4316	.2585	.0637	1137.67	1137.67	16.77	44.79	38.44	-115.03
40.000	1.7534	1.3055	.3431	.0469	1137.55	1137.55	12.68	46.10	41.22	-115.01
51.755	1.7149	1.1959	.4340	.0348	1138.62	1138.62	9.60	47.01	43.39	-115.15
66.964	1.6822	1.1020	.5264	.0260	1140.94	1140.94	7.28	47.59	45.13	-115.47
86.643	1.6525	1.0229	.6155	.0195	1144.77	1144.77	5.52	47.93	46.55	-115.99
112.104	1.6235	.9570	.6964	.0147	1150.59	1150.59	4.19	48.09	47.73	-116.79
145.048	1.5927	.9026	.7645	.0111	1159.32	1159.32	3.17	48.11	48.72	-117.98
187.674	1.5573	.8572	.8168	.0083	1172.50	1172.50	2.40	48.06	49.54	-119.77
242.825	1.5162	.8176	.8545	.0063	1190.78	1190.78	1.80	48.02	50.18	-122.27
314.184	1.4844	.7805	.9017	.0047	1203.03	1203.03	1.37	47.85	50.78	-123.94
406.513	1.4769	.7441	.9849	.0036	1199.05	1199.05	1.05	47.47	51.48	-123.40
525.975	1.4799	.7115	1.0798	.0028	1188.19	1188.19	.81	46.96	52.23	-121.91

SURFACE NORMAL COORDINATE (CM)

	1	2	3	4	5	6	7	8	9	10
0	0.	.1000E-05	.2000E-05	.3000E-05	.4000E-05	.5000E-05	.6000E-05	.7000E-05	.8000E-05	.9000E-05
1	.1000E-04	.1100E-04	.1200E-04	.1300E-04	.1400E-04	.1500E-04	.1600E-04	.1700E-04	.1800E-04	.1900E-04
2	.2000E-04	.2100E-04	.2200E-04	.2300E-04	.2400E-04	.2500E-04	.2600E-04	.2700E-04	.2800E-04	.2900E-04
3	.3000E-04	.3100E-04	.3200E-04	.3300E-04	.3400E-04	.3500E-04	.3600E-04	.3700E-04	.3800E-04	.3900E-04
4	.4000E-04	.4100E-04	.4200E-04	.4300E-04	.4400E-04	.4500E-04	.4600E-04	.4700E-04	.4800E-04	.4900E-04
5	.5000E-04	.5100E-04	.5200E-04	.5300E-04	.5400E-04	.5500E-04	.5600E-04	.5700E-04	.5800E-04	.5900E-04
6	.6000E-04	.6100E-04	.6200E-04	.6300E-04	.6400E-04	.6500E-04	.6600E-04	.6700E-04	.6800E-04	.6900E-04
7	.7000E-04	.7100E-04	.7200E-04	.7300E-04	.7400E-04	.7500E-04	.7600E-04	.7700E-04	.7800E-04	.7900E-04
8	.8000E-04	.8100E-04	.8200E-04	.8300E-04	.8400E-04	.8500E-04	.8600E-04	.8700E-04	.8800E-04	.8900E-04
9	.9000E-04	.9100E-04	.9200E-04	.9300E-04	.9400E-04	.9500E-04	.9600E-04	.9700E-04	.9800E-04	.9900E-04
10	.1000E-03	.1100E-03	.1200E-03	.1300E-03	.1400E-03	.1500E-03	.1600E-03	.1700E-03	.1800E-03	.1900E-03
11	.2000E-03	.2100E-03	.2200E-03	.2300E-03	.2400E-03	.2500E-03	.2600E-03	.2700E-03	.2800E-03	.2900E-03
12	.3000E-03	.3100E-03	.3200E-03	.3300E-03	.3400E-03	.3500E-03	.3600E-03	.3700E-03	.3800E-03	.3900E-03
13	.4000E-03	.4100E-03	.4200E-03	.4300E-03	.4400E-03	.4500E-03	.4600E-03	.4700E-03	.4800E-03	.4900E-03
14	.5000E-03	.5100E-03	.5200E-03	.5300E-03	.5400E-03	.5500E-03	.5600E-03	.5700E-03	.5800E-03	.5900E-03
15	.6000E-03	.6100E-03	.6200E-03	.6300E-03	.6400E-03	.6500E-03	.6600E-03	.6700E-03	.6800E-03	.6900E-03
16	.7000E-03	.7100E-03	.7200E-03	.7300E-03	.7400E-03	.7500E-03	.7600E-03	.7700E-03	.7800E-03	.7900E-03
17	.8000E-03	.8100E-03	.8200E-03	.8300E-03	.8400E-03	.8500E-03	.8600E-03	.8700E-03	.8800E-03	.8900E-03
18	.9000E-03	.9100E-03	.9200E-03	.9300E-03	.9400E-03	.9500E-03	.9600E-03	.9700E-03	.9800E-03	.9900E-03
19	.1000E-02	.1100E-02	.1200E-02	.1300E-02	.1400E-02	.1500E-02	.1600E-02	.1700E-02	.1800E-02	.1900E-02
20	.2000E-02	.2100E-02	.2200E-02	.2300E-02	.2400E-02	.2500E-02	.2600E-02	.2700E-02	.2800E-02	.2900E-02
21	.3000E-02	.3100E-02	.3200E-02	.3300E-02	.3400E-02	.3500E-02	.3600E-02	.3700E-02	.3800E-02	.3900E-02
22	.4000E-02	.4100E-02	.4200E-02	.4300E-02	.4400E-02	.4500E-02	.4600E-02	.4700E-02	.4800E-02	.4900E-02
23	.5000E-02	.5100E-02	.5200E-02	.5300E-02	.5400E-02	.5500E-02	.5600E-02	.5700E-02	.5800E-02	.5900E-02
24	.6000E-02	.6100E-02	.6200E-02	.6300E-02	.6400E-02	.6500E-02	.6600E-02	.6700E-02	.6800E-02	.6900E-02
25	.7000E-02	.7100E-02	.7200E-02	.7300E-02	.7400E-02	.7500E-02	.7600E-02	.7700E-02	.7800E-02	.7900E-02
26	.8000E-02	.8100E-02	.8200E-02	.8300E-02	.8400E-02	.8500E-02	.8600E-02	.8700E-02	.8800E-02	.8900E-02
27	.9000E-02	.9100E-02	.9200E-02	.9300E-02	.9400E-02	.9500E-02	.9600E-02	.9700E-02	.9800E-02	.9900E-02
28	.1000E-01	.1100E-01	.1200E-01	.1300E-01	.1400E-01	.1500E-01	.1600E-01	.1700E-01	.1800E-01	.1900E-01
29	.2000E-01	.2100E-01	.2200E-01	.2300E-01	.2400E-01	.2500E-01	.2600E-01	.2700E-01	.2800E-01	.2900E-01
30	.3000E-01	.3100E-01	.3200E-01	.3300E-01	.3400E-01	.3500E-01	.3600E-01	.3700E-01	.3800E-01	.3900E-01
31	.4000E-01	.4100E-01	.4200E-01	.4300E-01	.4400E-01	.4500E-01	.4600E-01	.4700E-01	.4800E-01	.4900E-01
32	.5000E-01	.5100E-01	.5200E-01	.5300E-01	.5400E-01	.5500E-01	.5600E-01	.5700E-01	.5800E-01	.5900E-01
33	.6000E-01	.6100E-01	.6200E-01	.6300E-01	.6400E-01	.6500E-01	.6600E-01	.6700E-01	.6800E-01	.6900E-01
34	.7000E-01	.7100E-01	.7200E-01	.7300E-01	.7400E-01	.7500E-01	.7600E-01	.7700E-01	.7800E-01	.7900E-01
35	.8000E-01	.8100E-01	.8200E-01	.8300E-01	.8400E-01	.8500E-01	.8600E-01	.8700E-01	.8800E-01	.8900E-01
36	.9000E-01	.9100E-01	.9200E-01	.9300E-01	.9400E-01	.9500E-01	.9600E-01	.9700E-01	.9800E-01	.9900E-01
37	.1000E+00	.1100E+00	.1200E+00	.1300E+00	.1400E+00	.1500E+00	.1600E+00	.1700E+00	.1800E+00	.1900E+00
38	.2000E+00	.2100E+00	.2200E+00	.2300E+00	.2400E+00	.2500E+00	.2600E+00	.2700E+00	.2800E+00	.2900E+00
39	.3000E+00	.3100E+00	.3200E+00	.3300E+00	.3400E+00	.3500E+00	.3600E+00	.3700E+00	.3800E+00	.3900E+00
40	.4000E+00	.4100E+00	.4200E+00	.4300E+00	.4400E+00	.4500E+00	.4600E+00	.4700E+00	.4800E+00	.4900E+00
41	.5000E+00	.5100E+00	.5200E+00	.5300E+00	.5400E+00	.5500E+00	.5600E+00	.5700E+00	.5800E+00	.5900E+00
42	.6000E+00	.6100E+00	.6200E+00	.6300E+00	.6400E+00	.6500E+00	.6600E+00	.6700E+00	.6800E+00	.6900E+00
43	.7000E+00	.7100E+00	.7200E+00	.7300E+00	.7400E+00	.7500E+00	.7600E+00	.7700E+00	.7800E+00	.7900E+00
44	.8000E+00	.8100E+00	.8200E+00	.8300E+00	.8400E+00	.8500E+00	.8600E+00	.8700E+00	.8800E+00	.8900E+00
45	.9000E+00	.9100E+00	.9200E+00	.9300E+00	.9400E+00	.9500E+00	.9600E+00	.9700E+00	.9800E+00	.9900E+00
46	.1000E+01									

CROSSFLOW VELOCITY (CM/SEC)

	1	2	3	4	5	6	7	8	9	10

0	0.	.2053E+00	.4114E+00	.6181E+00	.8256E+00	.1034E+01	.1243E+01	.1452E+01	.1662E+01	.1873E+01
1	.2085E+01	.2298E+01	.2511E+01	.2725E+01	.2939E+01	.3154E+01	.3370E+01	.3587E+01	.3805E+01	.4023E+01
2	.4242E+01	.4462E+01	.4682E+01	.4903E+01	.5125E+01	.5348E+01	.5571E+01	.5796E+01	.6021E+01	.6246E+01
3	.6473E+01	.6700E+01	.6928E+01	.7157E+01	.7386E+01	.7617E+01	.7848E+01	.8080E+01	.8312E+01	.8546E+01
4	.8780E+01	.9015E+01	.9251E+01	.9487E+01	.9725E+01	.9963E+01	.1020E+02	.1044E+02	.1068E+02	.1092E+02
5	.1117E+02	.1141E+02	.1165E+02	.1190E+02	.1214E+02	.1239E+02	.1264E+02	.1288E+02	.1313E+02	.1338E+02
6	.1363E+02	.1388E+02	.1414E+02	.1439E+02	.1464E+02	.1490E+02	.1515E+02	.1541E+02	.1567E+02	.1592E+02
7	.1618E+02	.1644E+02	.1670E+02	.1696E+02	.1723E+02	.1749E+02	.1775E+02	.1802E+02	.1828E+02	.1855E+02
8	.1882E+02	.1909E+02	.1936E+02	.1963E+02	.1990E+02	.2017E+02	.2044E+02	.2072E+02	.2099E+02	.2127E+02
9	.2154E+02	.2182E+02	.2210E+02	.2238E+02	.2266E+02	.2294E+02	.2322E+02	.2350E+02	.2379E+02	.2407E+02
10	.2436E+02	.2726E+02	.3027E+02	.3337E+02	.3657E+02	.3987E+02	.4328E+02	.4679E+02	.5041E+02	.5414E+02
11	.5799E+02	.6195E+02	.6602E+02	.7022E+02	.7453E+02	.7896E+02	.8351E+02	.8819E+02	.9298E+02	.9790E+02
12	.1029E+03	.1081E+03	.1134E+03	.1188E+03	.1243E+03	.1300E+03	.1358E+03	.1416E+03	.1477E+03	.1538E+03
13	.1600E+03	.1664E+03	.1728E+03	.1794E+03	.1861E+03	.1928E+03	.1997E+03	.2067E+03	.2138E+03	.2209E+03
14	.2282E+03	.2355E+03	.2430E+03	.2505E+03	.2581E+03	.2657E+03	.2735E+03	.2813E+03	.2892E+03	.2971E+03
15	.3052E+03	.3132E+03	.3214E+03	.3296E+03	.3378E+03	.3461E+03	.3545E+03	.3629E+03	.3713E+03	.3798E+03
16	.3883E+03	.3969E+03	.4055E+03	.4141E+03	.4228E+03	.4315E+03	.4402E+03	.4490E+03	.4578E+03	.4666E+03
17	.4754E+03	.4842E+03	.4931E+03	.5020E+03	.5109E+03	.5198E+03	.5288E+03	.5377E+03	.5467E+03	.5557E+03
18	.5647E+03	.5737E+03	.5827E+03	.5917E+03	.6007E+03	.6097E+03	.6187E+03	.6278E+03	.6368E+03	.6458E+03
19	.6549E+03	.7451E+03	.8349E+03	.9237E+03	.1011E+04	.1098E+04	.1182E+04	.1266E+04	.1348E+04	.1428E+04
20	.1506E+04	.1584E+04	.1659E+04	.1734E+04	.1807E+04	.1878E+04	.1949E+04	.2018E+04	.2086E+04	.2152E+04
21	.2218E+04	.2282E+04	.2345E+04	.2408E+04	.2469E+04	.2529E+04	.2589E+04	.2647E+04	.2705E+04	.2762E+04
22	.2818E+04	.2873E+04	.2927E+04	.2981E+04	.3034E+04	.3086E+04	.3137E+04	.3188E+04	.3238E+04	.3288E+04
23	.3337E+04	.3385E+04	.3433E+04	.3480E+04	.3527E+04	.3573E+04	.3619E+04	.3664E+04	.3708E+04	.3752E+04
24	.3796E+04	.3839E+04	.3882E+04	.3924E+04	.3966E+04	.4008E+04	.4049E+04	.4089E+04	.4129E+04	.4169E+04
25	.4209E+04	.4248E+04	.4287E+04	.4325E+04	.4363E+04	.4401E+04	.4438E+04	.4475E+04	.4512E+04	.4548E+04
26	.4584E+04	.4620E+04	.4655E+04	.4690E+04	.4725E+04	.4760E+04	.4794E+04	.4828E+04	.4862E+04	.4896E+04
27	.4929E+04	.4962E+04	.4995E+04	.5027E+04	.5060E+04	.5092E+04	.5123E+04	.5155E+04	.5186E+04	.5217E+04
28	.5248E+04	.5546E+04	.5825E+04	.6089E+04	.6337E+04	.6574E+04	.6799E+04	.7013E+04	.7219E+04	.7416E+04
29	.7606E+04	.7789E+04	.7965E+04	.8135E+04	.8300E+04	.8459E+04	.8614E+04	.8764E+04	.8910E+04	.9052E+04
30	.9190E+04	.9325E+04	.9456E+04	.9584E+04	.9710E+04	.9832E+04	.9952E+04	.1007E+05	.1018E+05	.1030E+05
31	.1041E+05	.1051E+05	.1062E+05	.1072E+05	.1082E+05	.1093E+05	.1102E+05	.1112E+05	.1122E+05	.1131E+05
32	.1140E+05	.1149E+05	.1158E+05	.1167E+05	.1175E+05	.1184E+05	.1192E+05	.1201E+05	.1209E+05	.1217E+05
33	.1225E+05	.1233E+05	.1240E+05	.1248E+05	.1255E+05	.1263E+05	.1270E+05	.1277E+05	.1285E+05	.1292E+05
34	.1299E+05	.1306E+05	.1312E+05	.1319E+05	.1326E+05	.1332E+05	.1339E+05	.1345E+05	.1352E+05	.1358E+05
35	.1364E+05	.1371E+05	.1377E+05	.1383E+05	.1389E+05	.1395E+05	.1401E+05	.1407E+05	.1412E+05	.1418E+05
36	.1424E+05	.1430E+05	.1435E+05	.1441E+05	.1446E+05	.1452E+05	.1457E+05	.1462E+05	.1468E+05	.1473E+05
37	.1478E+05	.1528E+05	.1574E+05	.1617E+05	.1658E+05	.1696E+05	.1732E+05	.1766E+05	.1799E+05	.1830E+05
38	.1860E+05	.1888E+05	.1916E+05	.1942E+05	.1968E+05	.1992E+05	.2016E+05			

AVERAGE RESISTANCE COEFFICIENT

	1	2	3	4	5	6	7	8	9	10
0	.1000E+01	.1000E+01	.1000E+01	.1000E+01	.1000E+01	.1000E+01	.1000E+01	.1000E+01	.1000E+01	.1000E+01
1	.1000E+01	.1000E+01	.1000E+01	.1000E+01	.1000E+01	.1000E+01	.1000E+01	.1000E+01	.1000E+01	.1000E+01
2	.9999E+00	.9999E+00	.9999E+00	.9999E+00	.9999E+00	.9999E+00	.9999E+00	.9999E+00	.9999E+00	.9999E+00
3	.9999E+00	.9999E+00	.9999E+00	.9998E+00	.9998E+00	.9998E+00	.9998E+00	.9998E+00	.9998E+00	.9998E+00
4	.9998E+00	.9998E+00	.9998E+00	.9997E+00	.9997E+00	.9997E+00	.9997E+00	.9997E+00	.9997E+00	.9997E+00
5	.9996E+00	.9996E+00	.9996E+00	.9996E+00	.9996E+00	.9996E+00	.9995E+00	.9995E+00	.9995E+00	.9995E+00
6	.9995E+00	.9994E+00	.9994E+00	.9994E+00	.9994E+00	.9994E+00	.9993E+00	.9993E+00	.9993E+00	.9993E+00
7	.9993E+00	.9992E+00	.9992E+00	.9992E+00	.9992E+00	.9991E+00	.9991E+00	.9991E+00	.9991E+00	.9990E+00
8	.9990E+00	.9990E+00	.9990E+00	.9989E+00	.9989E+00	.9989E+00	.9968E+00	.9988E+00	.9988E+00	.9987E+00
9	.9987E+00	.9987E+00	.9986E+00	.9986E+00	.9986E+00	.9985E+00	.9985E+00	.9985E+00	.9984E+00	.9984E+00
10	.9984E+00	.9980E+00	.9976E+00	.9971E+00	.9965E+00	.9959E+00	.9953E+00	.9946E+00	.9938E+00	.9929E+00
11	.9920E+00	.9910E+00	.9899E+00	.9887E+00	.9875E+00	.9861E+00	.9847E+00	.9832E+00	.9816E+00	.9799E+00
12	.9781E+00	.9762E+00	.9742E+00	.9721E+00	.9700E+00	.9677E+00	.9653E+00	.9629E+00	.9604E+00	.9577E+00
13	.9550E+00	.9522E+00	.9493E+00	.9463E+00	.9433E+00	.9401E+00	.9369E+00	.9337E+00	.9303E+00	.9269E+00
14	.9234E+00	.9199E+00	.9163E+00	.9127E+00	.9090E+00	.9053E+00	.9015E+00	.8977E+00	.8939E+00	.8900E+00

15	.8861E+00	.8822E+00	.8782E+00	.8742E+00	.8703E+00	.8662E+00	.8622E+00	.8582E+00	.8542E+00	.8501E+00
16	.8461E+00	.8420E+00	.8380E+00	.8339E+00	.8299E+00	.8259E+00	.8218E+00	.8178E+00	.8138E+00	.8098E+00
17	.8058E+00	.8018E+00	.7979E+00	.7939E+00	.7900E+00	.7861E+00	.7822E+00	.7783E+00	.7745E+00	.7706E+00
18	.7668E+00	.7630E+00	.7593E+00	.7555E+00	.7518E+00	.7481E+00	.7444E+00	.7408E+00	.7371E+00	.7335E+00
19	.7299E+00	.6954E+00	.6633E+00	.6336E+00	.6061E+00	.5808E+00	.5573E+00	.5357E+00	.5156E+00	.4969E+00
20	.4795E+00	.4633E+00	.4482E+00	.4341E+00	.4208E+00	.4083E+00	.3966E+00	.3855E+00	.3751E+00	.3652E+00
21	.3559E+00	.3470E+00	.3386E+00	.3306E+00	.3230E+00	.3157E+00	.3087E+00	.3021E+00	.2958E+00	.2897E+00
22	.2839E+00	.2783E+00	.2730E+00	.2678E+00	.2629E+00	.2581E+00	.2535E+00	.2491E+00	.2449E+00	.2408E+00
23	.2368E+00	.2329E+00	.2292E+00	.2257E+00	.2222E+00	.2188E+00	.2156E+00	.2124E+00	.2093E+00	.2064E+00
24	.2035E+00	.2007E+00	.1980E+00	.1953E+00	.1927E+00	.1902E+00	.1878E+00	.1854E+00	.1831E+00	.1809E+00
25	.1787E+00	.1765E+00	.1744E+00	.1724E+00	.1704E+00	.1685E+00	.1666E+00	.1647E+00	.1629E+00	.1611E+00
26	.1594E+00	.1577E+00	.1561E+00	.1544E+00	.1529E+00	.1513E+00	.1498E+00	.1483E+00	.1468E+00	.1454E+00
27	.1440E+00	.1427E+00	.1413E+00	.1400E+00	.1387E+00	.1374E+00	.1362E+00	.1350E+00	.1338E+00	.1326E+00
28	.1314E+00	.1209E+00	.1119E+00	.1043E+00	.9762E-01	.9179E-01	.8664E-01	.8205E-01	.7794E-01	.7424E-01
29	.7088E-01	.6782E-01	.6503E-01	.6246E-01	.6010E-01	.5791E-01	.5588E-01	.5399E-01	.5223E-01	.5059E-01
30	.4904E-01	.4760E-01	.4623E-01	.4495E-01	.4374E-01	.4259E-01	.4150E-01	.4047E-01	.3949E-01	.3856E-01
31	.3767E-01	.3683E-01	.3602E-01	.3525E-01	.3451E-01	.3380E-01	.3312E-01	.3247E-01	.3184E-01	.3124E-01
32	.3066E-01	.3011E-01	.2957E-01	.2905E-01	.2856E-01	.2807E-01	.2761E-01	.2716E-01	.2673E-01	.2631E-01
33	.2590E-01	.2550E-01	.2512E-01	.2475E-01	.2439E-01	.2404E-01	.2370E-01	.2338E-01	.2306E-01	.2274E-01
34	.2244E-01	.2215E-01	.2186E-01	.2158E-01	.2131E-01	.2105E-01	.2079E-01	.2054E-01	.2029E-01	.2005E-01
35	.1982E-01	.1959E-01	.1936E-01	.1915E-01	.1893E-01	.1873E-01	.1852E-01	.1832E-01	.1813E-01	.1794E-01
36	.1775E-01	.1757E-01	.1739E-01	.1722E-01	.1704E-01	.1688E-01	.1671E-01	.1655E-01	.1639E-01	.1624E-01
37	.1609E-01	.1471E-01	.1355E-01	.1257E-01	.1172E-01	.1098E-01	.1033E-01	.9752E-02	.9239E-02	.8778E-02
38	.8362E-02	.7984E-02	.7640E-02	.7324E-02	.7035E-02	.6767E-02	.6520E-02			

E. SAMPLE CASE 4

This case is the first of the nonsteady state pressure coupled response calculations. The method employed in this case is the small perturbation technique. Again, the propellant oxidizer distribution is unimodal with a mean diameter of 40 microns and a mode width parameter equal to two. The oxidizer mass fraction is equal to .88 and all other default values are assumed. After presenting the nonsteady state response parameters for each of the individual pseudo-propellants, the overall propellant response is presented as a function of the frequency. As is the case with all the nonsteady state response output, the real and imaginary parts of the complex response function is given along with normalized response values, the magnitudes of the response function and the phase angles associated with each frequency.

```
$FLAG $
$PARMST $
$PROPDT $
$ALUMDT $
$EROSDT $
$RESPDT IRPHM=1 $
$OXDIST DBARI(1)=40., SIGMAI(1)=2.0, ALFAI(1)=.88, MODES=1 $
```

Figure 5. Data Deck for Sample Case Number 4.

***** PETITE ENSEMBLE MODEL(PEM) INPUT/OUTPUT PARAMETERS *****

TZERO-INITIAL SOLID PROPELLANT TEMPERATURE	294.15	KELVIN			
XALFA-OXIDIZER TOTAL MASS FRACTION	.8800		NPROP-PROPELLANT NUMBER	0	
AOXID-OXIDIZER TYPE	AP		AFUEL-FUEL BINDER TYPE	HTPB	
QL-OXIDIZER HEAT OF DECOMPOSITION	0.00	CAL/GRAM	QFUEL-FUEL HEAT OF PYROLYSIS	433.00	CAL/GRAM
RHOX-OXIDIZER DENSITY	1.950	G/CM**3	RHOF-FUEL DENSITY	.920	G/CM**3
AOX-OXIDIZER DECOMPOSITION FREQ. FACTOR	.166E+05	G/CM**2-S	AF-FUEL PYROLYSIS FREQUENCY FACTOR	.299E+03	G/CM**2-S
EOX-OXIDIZER DECOMPOSITION ACTIV. ENERGY	21000.	CAL/MOLE	EF-FUEL PYROLYSIS ACTIVATION ENERGY	16900.	CAL/MOLE
AAP-OXIDIZER FLAME FREQUENCY FACTOR	2500000.	CM3-G/S-A	APF-PRIMARY FLAME FREQUENCY FACTOR	1400.	CM3-G/S-A
EAP-OXIDIZER FLAME ACTIVATION ENERGY	25000.	CAL/MOLE	EPF-PRIMARY FLAME ACTIVATION ENERGY	15000.	CAL/MOLE
DELAP-OXIDIZER FLAME REACTION ORDER	1.0		DELPF-PRIMARY FLAME REACTION ORDER	1.5	
PFMW-PRIMARY FLAME M.W. (1000 PSIA)	25.99	G/GMOLE	XNUPF-PRIMARY FLAME STOICHIOMETRY VARIABLE	9.30	
FFMW-FINAL FLAME M.W. (1000 PSIA)	26.95	G/GMOLE	XNUFF-FINAL FLAME STOICHIOMETRY VARIABLE	9.30	
CP-GAS PHASE SPECIFIC HEAT CAPACITY	.40	CAL/G-K	CIGN-IGNITION DELAY PROPORTIONALITY VALUE	190.	S-ATM/CM
XLAMB-GAS PHASE THERMAL CONDUCTIVITY	.50000E-05	CAL/CM-S-K	POWD-IGNITION DELAY DIAMETER EXPONENT	.800	
GAMMA-DIFFUSION COEFFICIENT PARAMETER	.760E-05	CM2-A/S-K	POWIG-IGNITION DELAY PRESSURE EXPONENT	.721	
PLAMB-SOLID PHASE THERMAL CONDUCTIVITY	.00030	CAL/CM-S-K	CS-SOLID PHASE SPECIFIC HEAT	.20	
FACTOR-FLAME TEMPERATURE PARAMETER	.50				

PSTART-STARTING PRESSURE (RATE/PRESSURE)	68.0272	ATMS	LIMBES-NUMBER OF TERMS (BURKE SCHUMANN)	40	
PSTOP-STOPPING PRESSURE (RATE/PRESSURE)	68.0272	ATMS	ERRBES-MINIMUM VALUE OF LAST TERM IN SERIES	.100E-06	
NPRESS-NUMBER OF PRESSURES CONSIDERED	1		ESTART-INITIAL N.D. DIFFUSION HEIGHT	.100E+00	
NDPM-NUMBER OF DIAMETERS/MODE-(RATE CAL.)	21		XHUHI-MAX VOLUME FRACTION (BURKE SCHUMANN)	.980	
NXDPM-NUMBER OF DIAMETERS/MODE-(C-CAL.)	201		XHULOW-MIN VOLUME FRACTION (BURKE SCHUMANN)	.300	
UINF-CROSS FLOW VELOCITY-EROSIVE BURNING	0.	CM/SEC	CPRIME-CONSTANT IN PRANDTL MIXING LENGTH EXP.	.16	
YSTART-STARTING VALUE OF Y-COORDINATE(CM)	0.000000		COND-PROP. CONST.-DIFFUSION COEFFICIENT	1.00	
YSTOP-STOPPING VALUE OF Y-COORDINATE(CM)	1.000000		CONC-PROP. CONST.-THERMAL CONDUCTIVITY	1.00	
NSTEP-NUMBER OF STEPS-TURB. VEL. PROFILE	461		ITERO-NUMBER OF EROSIVE BURNING ITERATIONS	20	
INSTEP-STEPS/UNIT LN10(Y-COORDINATE)	100		NCYC-NUMBER OF LOG10 CYCLES USED	5	

PPERD-PRESSURE PERTURBATION (NONSTEADY)	.50	PERCENT	***** METAL PARAMETERS *****		
TPERD-TEMPERATURE PERTURBATION (NONSTEADY)	.50	PERCENT	ALTYPE-ALUMINUM TYPE	NONE	
BFAC-COHEN POSTULATE CONSTANT (MAGNITUDE)	1360.000	MICRON	BETA-MASS FRACTION OF METAL	0.0000	
FFAC-COHEN POSTULATE CONSTANT (FREQUENCY)	4.720		QM-LATENT HEAT OF METAL LIQUIFACTION	96.00	CAL/GRAM
OSTART-STARTING FREQUENCY (NONS. RESPONSE)	10.	HERTZ	RHOM-METAL DENSITY	2.710	G/CM**3
OSTOP-STOPPING FREQUENCY (NONS. RESPONSE)	100000.	HERTZ	DBARM-MEAN DIAMETER OF METAL DISTRIBUTION	6.000	MICRON
NOMEG-NUMBER OF FREQUENCIES CONSIDERED	81		SIGMAM-WIDTH PARAMETER OF METAL DISTRIBUTION	1.0000	

***** CATALYST PARAMETERS *****			***** ADDITIVE PARAMETERS *****		
CATYPE-CATALYST TYPE	NONE				
ALFCAT-MASS FRACTION OF CATALYST	0.0000		ADTYPE-ADDITIVE 1 TYPE	NONE	
SPSUR-SPECIFIC SURFACE OF CATALYST	0.0000	M**2/GRAM	ALFADD-ADDITIVE 1 MASS FRACTION	0.0000	
CAP-AP FLAME FACTOR (EXPONENTIAL)	0.00				
EAP2-AP FLAME FACTOR (ACT. ENERGY)	0.00	CAL/MOLE	ADTYPE-ADDITIVE 2 TYPE	NONE	
CPF-PF FLAME FACTOR (EXPONENTIAL)	14.96		ALFADD-ADDITIVE 2 MASS FRACTION	0.0000	
EPF2-PF FLAME FACTOR (ACT. ENERGY)	2610.00	CAL/MOLE			

XNUT-OXIDIZER VOLUME FRACTION	.77578		CX-VALUE OF C IN VF=C*DZERO**N EXPRESS.	.151E+00	
RHOT-TOTAL PROPELLANT DENSITY	1.71905	G/CM**3	XN-VALUE OF N IN VF=C*DZERO**N EXPRESS.	3.000	
RHOFA-FUEL-ALUMINUM MIXTURE DENSITY	.92000	G/CM**3	MODES-NUMBER OF OXIDIZER MODES	1	

MODE NUMBER	MEAN DIAMETER (DBARI)	MODE WIDTH PARAMETER (SIGMAI)	MASS FRACTION (ALFAI)	MASS FRACTION (CORR)
1	40.000	2.0000	.8800	

PRESSURE IS 1000.0 PSIA THE OXID/FUEL BEING CONSIDERED IS AP/ HTPB
INITIAL PROPELLANT TEMPERATURE IS 294.2 DEGREES KELVIN

DZERO (MICRONS)	BETAF	XSTPD (MICRONS)	XSTPF (MICRONS)	XSTAP (MICRONS)	XSTFD (MICRONS)	TF (K)	TS (K)	TSPF ...	TSFF (PERCENT)	TSAP ...	TSQL (K)	TSQF (K)	TSQM (K)	SOXP
3.04	1.000	1.033	.920	2.670	0.000	2998.3	1191.64	100.00	0.00	0.00	0.00	-295.23	0.00	2.829
3.94	1.000	1.384	.866	2.515	0.000	2998.3	1185.97	100.00	0.00	0.00	0.00	-295.23	0.00	2.780
5.09	.818	1.858	.798	2.318	.526	2998.3	1178.23	92.73	5.89	1.37	0.00	-295.23	0.00	2.718
6.59	.540	2.483	.704	2.044	2.845	2998.3	1166.05	81.77	11.92	6.31	0.00	-295.23	0.00	2.631
8.53	.360	3.350	.633	1.838	3.639	2998.3	1156.17	66.54	20.35	13.11	0.00	-295.23	0.00	2.557
11.03	.239	4.556	.573	1.662	4.760	2998.3	1147.04	51.82	26.87	21.31	0.00	-295.23	0.00	2.487
14.27	.158	6.245	.519	1.507	6.344	2998.3	1138.37	39.01	30.62	30.37	0.00	-295.23	0.00	2.418
18.47	.104	8.634	.471	1.367	8.587	2998.3	1130.00	28.52	31.63	39.85	0.00	-295.23	0.00	2.350
23.89	.068	12.045	.427	1.241	11.788	2998.3	1121.92	20.32	30.38	49.30	0.00	-295.23	0.00	2.282
30.92	.044	16.976	.389	1.128	16.402	2998.3	1114.25	14.13	27.54	58.33	0.00	-295.23	0.00	2.213
40.00	.028	24.207	.354	1.029	23.138	2998.3	1107.14	9.62	23.78	66.61	0.00	-295.23	0.00	2.145
51.75	.018	34.972	.325	.942	33.121	2998.3	1100.78	6.41	19.67	73.92	0.00	-295.23	0.00	2.077
66.96	.011	51.268	.299	.868	48.162	2998.3	1095.35	4.20	15.63	80.18	0.00	-295.23	0.00	2.007
86.64	.007	76.346	.278	.806	71.215	2998.3	1091.07	2.70	11.95	85.35	0.00	-295.23	0.00	1.934
112.10	.004	115.551	.260	.754	107.140	2998.3	1088.15	1.71	8.80	89.49	0.00	-295.23	0.00	1.858
145.05	.003	177.641	.245	.711	163.920	2998.3	1086.80	1.07	6.27	92.67	0.00	-295.23	0.00	1.773
187.67	.002	276.807	.233	.675	254.523	2998.3	1087.20	.66	4.34	95.01	0.00	-295.23	0.00	1.678
242.83	.001	435.578	.222	.644	399.598	2998.3	1089.53	.40	2.94	96.66	0.00	-295.23	0.00	1.568
314.18	.001	688.895	.212	.615	631.275	2998.3	1093.85	.24	1.97	97.79	0.00	-295.23	0.00	1.440
406.51	.000	1091.063	.202	.586	999.583	2998.3	1099.83	.15	1.32	98.54	0.00	-295.23	0.00	1.303
525.97	.000	1737.133	.193	.561	1591.777	2998.3	1105.73	.09	.87	99.04	0.00	-295.23	0.00	1.183

DZERO (MICRONS)	RATE (CM/SEC)	XNUV	ALFAV	RHOV (G/CM**3)	FSKP	XLAMAP (CAL/CM-S-K)	XLAMPF (CAL/CM-S-K)	XLAMFF (CAL/CM-S-K)
3.04	3.3883	.7758	.8800	1.7190	.0005	.1801E-03	.2289E-03	.2289E-03
3.94	3.1912	.7758	.8800	1.7190	.0019	.1799E-03	.2287E-03	.2287E-03
5.09	2.9420	.7758	.8800	1.7190	.0061	.1797E-03	.2285E-03	.2285E-03
6.59	2.5937	.7758	.8800	1.7190	.0172	.1792E-03	.2282E-03	.2282E-03
8.53	2.3330	.7758	.8800	1.7190	.0421	.1789E-03	.2279E-03	.2279E-03
11.03	2.1096	.7758	.8800	1.7190	.0901	.1786E-03	.2276E-03	.2276E-03
14.27	1.9123	.7758	.8800	1.7190	.1677	.1783E-03	.2274E-03	.2274E-03
18.47	1.7347	.7758	.8800	1.7190	.2720	.1780E-03	.2272E-03	.2272E-03
23.89	1.5747	.7758	.8800	1.7190	.3842	.1777E-03	.2269E-03	.2269E-03
30.92	1.4316	.7758	.8800	1.7190	.4727	.1774E-03	.2267E-03	.2267E-03
40.00	1.3055	.7758	.8800	1.7190	.5065	.1772E-03	.2265E-03	.2265E-03
51.75	1.1959	.7758	.8800	1.7190	.4727	.1769E-03	.2264E-03	.2264E-03
66.96	1.1020	.7758	.8800	1.7190	.3842	.1768E-03	.2262E-03	.2262E-03
86.64	1.0229	.7758	.8800	1.7190	.2720	.1766E-03	.2261E-03	.2261E-03
112.10	.9570	.7758	.8800	1.7190	.1677	.1765E-03	.2260E-03	.2260E-03
145.05	.9026	.7758	.8800	1.7190	.0901	.1765E-03	.2260E-03	.2260E-03
187.67	.8572	.7758	.8800	1.7190	.0421	.1765E-03	.2260E-03	.2260E-03
242.83	.8176	.7758	.8800	1.7190	.0172	.1765E-03	.2260E-03	.2260E-03
314.18	.7805	.7758	.8800	1.7190	.0061	.1767E-03	.2262E-03	.2262E-03
406.51	.7441	.7758	.8800	1.7190	.0019	.1769E-03	.2263E-03	.2263E-03
525.97	.7115	.7758	.8800	1.7190	.0005	.1771E-03	.2265E-03	.2265E-03

MODE NUMBER 1 SERIES RATE = 1.3638 CM/SEC PARALLEL RATE = 1.2926 CM/SEC BETAR = .3591

*** HAMANN PRESSURE COUPLED REPONSE CALCULATIONS ***

JJ	DZERO (MICRONS)	RATE (CM/S)	GRAD	C(JJ,1)	C(JJ,2)	C(JJ,3)	C(JJ,4)	PXN
1	3.042	3.3883	1348.1705	.1917E-01	.1637E+02	.8542E+01	.1762E+02	.60339
2	3.936	3.1912	1263.5188	.2265E-01	.1457E+02	.8525E+01	.1660E+02	.55879
3	5.093	2.9420	1157.0045	.2634E-01	.1120E+02	.8512E+01	.1390E+02	.47928
4	6.589	2.5937	1009.1640	.2960E-01	.9724E+01	.8512E+01	.1264E+02	.44021
5	8.525	2.3330	899.8243	.3377E-01	.9148E+01	.8496E+01	.1270E+02	.41370
6	11.031	2.1056	807.0325	.3868E-01	.8622E+01	.8471E+01	.1265E+02	.39144
7	14.272	1.9123	725.8395	.4440E-01	.8008E+01	.8435E+01	.1218E+02	.37262
8	18.467	1.7347	653.4633	.5101E-01	.7305E+01	.8388E+01	.1118E+02	.35767
9	23.893	1.5747	588.8021	.5864E-01	.6559E+01	.8329E+01	.9727E+01	.34726
10	30.915	1.4316	531.5397	.6751E-01	.5820E+01	.8254E+01	.7982E+01	.34158
11	40.000	1.3055	481.5223	.7796E-01	.5126E+01	.8161E+01	.6131E+01	.34031
12	51.755	1.1959	438.4788	.9042E-01	.4499E+01	.8044E+01	.4335E+01	.34302
13	66.964	1.1020	402.0077	.1055E+00	.3945E+01	.7895E+01	.2697E+01	.34944
14	86.643	1.0229	371.6231	.1240E+00	.3467E+01	.7707E+01	.1283E+01	.35942
15	112.104	.9570	346.7390	.1470E+00	.3055E+01	.7466E+01	.1284E+00	.37255
16	145.048	.9026	326.6104	.1758E+00	.2697E+01	.7156E+01	-.7530E+00	.38809
17	187.674	.8572	310.2831	.2113E+00	.2378E+01	.6760E+01	-.1367E+01	.40508
18	242.825	.8176	296.6007	.2534E+00	.2082E+01	.6267E+01	-.1739E+01	.42251
19	314.184	.7805	284.3248	.2960E+00	.1804E+01	.5704E+01	-.1915E+01	.43851
20	406.513	.7441	272.5669	.3146E+00	.1568E+01	.5242E+01	-.2013E+01	.44516
21	525.975	.7115	262.0972	.2426E+00	.1458E+01	.5427E+01	-.2364E+01	.41860

NDF	OMEGA (CPS)	RE(RSP/N)	IM(RSP/N)	RE(RSP)	IM(RSP)	MAG(RSP)	PHASE (DEGREES)	MAG(RSP/N)
.295E-01	.100E+02	.100E+01	.173E-01	.356E+00	.615E-02	.357E+00	.989E+00	.100E+01
.331E-01	.112E+02	.100E+01	.194E-01	.357E+00	.689E-02	.357E+00	.111E+01	.100E+01
.371E-01	.126E+02	.100E+01	.217E-01	.357E+00	.772E-02	.357E+00	.124E+01	.100E+01
.416E-01	.141E+02	.100E+01	.243E-01	.357E+00	.864E-02	.357E+00	.139E+01	.100E+01
.467E-01	.158E+02	.100E+01	.272E-01	.357E+00	.967E-02	.357E+00	.155E+01	.100E+01
.524E-01	.178E+02	.100E+01	.304E-01	.357E+00	.108E-01	.357E+00	.173E+01	.100E+01
.588E-01	.200E+02	.100E+01	.339E-01	.358E+00	.121E-01	.358E+00	.193E+01	.100E+01
.660E-01	.224E+02	.101E+01	.378E-01	.358E+00	.135E-01	.358E+00	.216E+01	.101E+01
.740E-01	.251E+02	.101E+01	.422E-01	.358E+00	.150E-01	.359E+00	.240E+01	.101E+01
.831E-01	.282E+02	.101E+01	.469E-01	.359E+00	.167E-01	.359E+00	.267E+01	.101E+01
.932E-01	.316E+02	.101E+01	.522E-01	.360E+00	.186E-01	.360E+00	.296E+01	.101E+01
.105E+00	.355E+02	.101E+01	.579E-01	.360E+00	.206E-01	.361E+00	.327E+01	.101E+01
.117E+00	.398E+02	.101E+01	.640E-01	.361E+00	.228E-01	.362E+00	.361E+01	.102E+01
.132E+00	.447E+02	.102E+01	.707E-01	.362E+00	.252E-01	.363E+00	.397E+01	.102E+01
.148E+00	.501E+02	.102E+01	.778E-01	.364E+00	.277E-01	.365E+00	.435E+01	.103E+01
.166E+00	.562E+02	.103E+01	.854E-01	.365E+00	.304E-01	.367E+00	.476E+01	.103E+01
.186E+00	.631E+02	.103E+01	.934E-01	.367E+00	.333E-01	.369E+00	.517E+01	.104E+01
.209E+00	.708E+02	.104E+01	.102E+00	.370E+00	.362E-01	.371E+00	.560E+01	.104E+01
.234E+00	.794E+02	.105E+01	.110E+00	.372E+00	.393E-01	.374E+00	.603E+01	.105E+01
.263E+00	.891E+02	.105E+01	.119E+00	.375E+00	.425E-01	.377E+00	.647E+01	.106E+01
.295E+00	.100E+03	.106E+01	.129E+00	.378E+00	.458E-01	.381E+00	.690E+01	.107E+01
.331E+00	.112E+03	.107E+01	.138E+00	.382E+00	.490E-01	.385E+00	.731E+01	.108E+01
.371E+00	.126E+03	.108E+01	.147E+00	.386E+00	.522E-01	.390E+00	.770E+01	.109E+01
.416E+00	.141E+03	.110E+01	.156E+00	.391E+00	.554E-01	.395E+00	.807E+01	.111E+01
.467E+00	.158E+03	.111E+01	.164E+00	.396E+00	.584E-01	.400E+00	.840E+01	.112E+01
.524E+00	.178E+03	.113E+01	.172E+00	.401E+00	.612E-01	.406E+00	.868E+01	.114E+01

.588E+00	.200E+03	.114E+01	.179E+00	.407E+00	.638E-01	.412E+00	.892E+01	.116E+01
.660E+00	.224E+03	.116E+01	.186E+00	.413E+00	.661E-01	.418E+00	.909E+01	.118E+01
.740E+00	.251E+03	.118E+01	.191E+00	.420E+00	.680E-01	.425E+00	.921E+01	.119E+01
.831E+00	.282E+03	.120E+01	.195E+00	.427E+00	.695E-01	.433E+00	.925E+01	.121E+01
.932E+00	.316E+03	.122E+01	.198E+00	.434E+00	.705E-01	.440E+00	.922E+01	.124E+01
.105E+01	.355E+03	.124E+01	.199E+00	.442E+00	.709E-01	.448E+00	.911E+01	.126E+01
.117E+01	.398E+03	.126E+01	.198E+00	.450E+00	.706E-01	.455E+00	.892E+01	.128E+01
.132E+01	.447E+03	.129E+01	.196E+00	.458E+00	.697E-01	.463E+00	.866E+01	.130E+01
.148E+01	.501E+03	.131E+01	.191E+00	.466E+00	.680E-01	.470E+00	.831E+01	.132E+01
.166E+01	.562E+03	.133E+01	.184E+00	.473E+00	.655E-01	.478E+00	.788E+01	.134E+01
.186E+01	.631E+03	.135E+01	.175E+00	.481E+00	.623E-01	.485E+00	.738E+01	.136E+01
.209E+01	.708E+03	.137E+01	.164E+00	.488E+00	.582E-01	.492E+00	.681E+01	.138E+01
.234E+01	.794E+03	.139E+01	.150E+00	.495E+00	.535E-01	.498E+00	.617E+01	.140E+01
.263E+01	.891E+03	.141E+01	.135E+00	.501E+00	.481E-01	.503E+00	.548E+01	.141E+01
.295E+01	.100E+04	.142E+01	.118E+00	.506E+00	.421E-01	.508E+00	.475E+01	.143E+01
.331E+01	.112E+04	.144E+01	.998E-01	.511E+00	.355E-01	.512E+00	.398E+01	.144E+01
.371E+01	.126E+04	.145E+01	.802E-01	.515E+00	.286E-01	.516E+00	.317E+01	.145E+01
.416E+01	.141E+04	.146E+01	.597E-01	.518E+00	.212E-01	.519E+00	.235E+01	.146E+01
.467E+01	.158E+04	.146E+01	.384E-01	.520E+00	.137E-01	.521E+00	.151E+01	.146E+01
.524E+01	.178E+04	.147E+01	.168E-01	.522E+00	.597E-02	.522E+00	.656E+00	.147E+01
.588E+01	.200E+04	.147E+01	-.509E-02	.522E+00	-.181E-02	.522E+00	-.199E+00	.147E+01
.660E+01	.224E+04	.147E+01	-.269E-01	.522E+00	-.959E-02	.522E+00	-.105E+01	.147E+01
.740E+01	.251E+04	.146E+01	-.486E-01	.521E+00	-.173E-01	.521E+00	-.190E+01	.146E+01
.831E+01	.282E+04	.146E+01	-.699E-01	.519E+00	-.249E-01	.519E+00	-.275E+01	.146E+01
.932E+01	.316E+04	.145E+01	-.906E-01	.516E+00	-.323E-01	.517E+00	-.358E+01	.145E+01
.105E+02	.355E+04	.144E+01	-.111E+00	.512E+00	-.394E-01	.514E+00	-.440E+01	.144E+01
.117E+02	.398E+04	.143E+01	-.130E+00	.508E+00	-.463E-01	.510E+00	-.520E+01	.143E+01
.132E+02	.447E+04	.141E+01	-.149E+00	.503E+00	-.529E-01	.506E+00	-.600E+01	.142E+01
.148E+02	.501E+04	.140E+01	-.166E+00	.498E+00	-.591E-01	.502E+00	-.677E+01	.141E+01
.166E+02	.562E+04	.138E+01	-.183E+00	.492E+00	-.651E-01	.496E+00	-.753E+01	.139E+01
.186E+02	.631E+04	.136E+01	-.198E+00	.486E+00	-.706E-01	.491E+00	-.827E+01	.138E+01
.209E+02	.708E+04	.135E+01	-.213E+00	.479E+00	-.758E-01	.485E+00	-.900E+01	.136E+01
.234E+02	.794E+04	.132E+01	-.227E+00	.472E+00	-.807E-01	.478E+00	-.971E+01	.134E+01
.263E+02	.891E+04	.130E+01	-.239E+00	.464E+00	-.851E-01	.472E+00	-.104E+02	.132E+01
.295E+02	.100E+05	.128E+01	-.250E+00	.456E+00	-.892E-01	.465E+00	-.111E+02	.131E+01
.331E+02	.112E+05	.126E+01	-.261E+00	.448E+00	-.929E-01	.457E+00	-.117E+02	.128E+01
.371E+02	.126E+05	.123E+01	-.270E+00	.439E+00	-.962E-01	.450E+00	-.124E+02	.126E+01
.416E+02	.141E+05	.121E+01	-.279E+00	.431E+00	-.992E-01	.442E+00	-.130E+02	.124E+01
.467E+02	.158E+05	.118E+01	-.286E+00	.422E+00	-.102E+00	.434E+00	-.136E+02	.122E+01
.524E+02	.178E+05	.116E+01	-.292E+00	.413E+00	-.104E+00	.426E+00	-.142E+02	.120E+01
.588E+02	.200E+05	.113E+01	-.298E+00	.403E+00	-.106E+00	.417E+00	-.147E+02	.117E+01
.660E+02	.224E+05	.111E+01	-.302E+00	.394E+00	-.108E+00	.409E+00	-.153E+02	.115E+01
.740E+02	.251E+05	.108E+01	-.306E+00	.385E+00	-.109E+00	.400E+00	-.158E+02	.112E+01
.831E+02	.282E+05	.105E+01	-.308E+00	.376E+00	-.110E+00	.391E+00	-.163E+02	.110E+01
.932E+02	.316E+05	.103E+01	-.310E+00	.366E+00	-.110E+00	.382E+00	-.168E+02	.107E+01
.105E+03	.355E+05	.100E+01	-.311E+00	.357E+00	-.111E+00	.374E+00	-.172E+02	.105E+01
.117E+03	.398E+05	.976E+00	-.311E+00	.348E+00	-.111E+00	.365E+00	-.177E+02	.102E+01
.132E+03	.447E+05	.950E+00	-.311E+00	.338E+00	-.111E+00	.356E+00	-.181E+02	.100E+01
.148E+03	.501E+05	.924E+00	-.310E+00	.329E+00	-.110E+00	.347E+00	-.185E+02	.975E+00
.166E+03	.562E+05	.899E+00	-.308E+00	.320E+00	-.110E+00	.338E+00	-.189E+02	.950E+00
.186E+03	.631E+05	.874E+00	-.306E+00	.311E+00	-.109E+00	.330E+00	-.193E+02	.926E+00
.209E+03	.708E+05	.849E+00	-.303E+00	.302E+00	-.108E+00	.321E+00	-.196E+02	.901E+00
.234E+03	.794E+05	.825E+00	-.299E+00	.294E+00	-.107E+00	.312E+00	-.200E+02	.877E+00
.263E+03	.891E+05	.801E+00	-.295E+00	.285E+00	-.105E+00	.304E+00	-.203E+02	.853E+00
.295E+03	.100E+06	.777E+00	-.291E+00	.277E+00	-.104E+00	.295E+00	-.205E+02	.830E+00

F. SAMPLE CASE 5

This case is a pressure coupled response calculation using the Zeldovich/Novozhilov method. Again, the propellant oxidizer distribution is unimodal with a mean diameter of 40 microns and a mode width parameter equal to two. The oxidizer mass fraction is equal to .88 and all other default values are assumed.

```
$FLAG $
$PARMST $
$PROPDT $
$ALUMDT $
EROSDT $
$RESPDT IRPZN=1 $
$OXDIST DBARI(1)=40., SIGMAI(1)=2.0, ALFAI(1)=.88, MODES=1 $
```

Figure 6. Data Deck for Sample Case Number 5.

*** ZELDOVICH/NOVOZHILOV PRESSURE COUPLED RESPONSE CALCULATIONS ***

	DZERO (MICRONS)	PXK	PXR	PXN	PXM	PXD	PXS	ES1	ES2
1	3.042	.4885E+00	.5721E-01	.6023E+00	.6829E-01	.1097E-02	.5443E-01	27728.15	26845.47
2	3.936	.4904E+00	.5754E-01	.5579E+00	.6280E-01	.1303E-02	.5499E-01	27839.76	26709.52
3	5.093	.2405E+00	.2826E-01	.4770E+00	.5296E-01	.7443E-03	.2721E-01	28102.45	26551.02
4	6.589	.4707E+00	.5531E-01	.4399E+00	.4821E-01	.1637E-02	.5398E-01	28270.07	26367.98
5	8.525	.6985E+00	.8223E-01	.4133E+00	.4468E-01	.2777E-02	.8103E-01	28501.29	26172.55
6	11.031	.8571E+00	.1012E+00	.3910E+00	.4160E-01	.3915E-02	.1005E+00	28808.07	25958.05
7	14.272	.9622E+00	.1141E+00	.3722E+00	.3888E-01	.5066E-02	.1140E+00	29203.90	25720.43
8	18.467	.1039E+01	.1239E+00	.3574E+00	.3654E-01	.6320E-02	.1243E+00	29693.12	25455.75
9	23.893	.1104E+01	.1325E+00	.3471E+00	.3465E-01	.7772E-02	.1333E+00	30272.73	25159.43
10	30.915	.1172E+01	.1420E+00	.3416E+00	.3321E-01	.9583E-02	.1429E+00	30940.52	24825.44
11	40.000	.1248E+01	.1529E+00	.3404E+00	.3216E-01	.1192E-01	.1534E+00	31705.99	24445.08
12	51.755	.1334E+01	.1659E+00	.3432E+00	.3143E-01	.1500E-01	.1654E+00	32593.64	24006.03
13	66.964	.1433E+01	.1815E+00	.3496E+00	.3092E-01	.1914E-01	.1788E+00	33641.73	23490.76
14	86.643	.1541E+01	.2000E+00	.3596E+00	.3058E-01	.2480E-01	.1934E+00	34913.66	22874.44
15	112.104	.1655E+01	.2217E+00	.3728E+00	.3024E-01	.3259E-01	.2084E+00	36529.13	22122.63
16	145.048	.1765E+01	.2466E+00	.3883E+00	.2970E-01	.4335E-01	.2227E+00	38711.75	21190.00
17	187.674	.1860E+01	.2750E+00	.4053E+00	.2868E-01	.5812E-01	.2345E+00	41842.78	20024.32
18	242.825	.1926E+01	.3073E+00	.4226E+00	.2700E-01	.7787E-01	.2422E+00	46418.29	18589.80
19	314.184	.1958E+01	.3432E+00	.4386E+00	.2500E-01	.1016E+00	.2448E+00	52157.43	16960.01
20	406.513	.1971E+01	.3761E+00	.4452E+00	.2492E-01	.1183E+00	.2447E+00	53288.05	15635.39
21	525.975	.2063E+01	.3808E+00	.4187E+00	.3250E-01	.9238E-01	.2542E+00	38568.85	16220.71

NDF	OMEGA (CPS)	RE(RSP/N)	IM(RSP/N)	RE(RSP)	IM(RSP)	MAG(RSP)	PHASE (DEGREES)	MAG(RSP/N)
.295E-01	.100E+02	.100E+01	.373E-01	.356E+00	.133E-01	.357E+00	.214E+01	.100E+01
.331E-01	.112E+02	.100E+01	.419E-01	.357E+00	.149E-01	.357E+00	.239E+01	.100E+01
.371E-01	.126E+02	.100E+01	.469E-01	.357E+00	.167E-01	.357E+00	.268E+01	.100E+01
.416E-01	.141E+02	.100E+01	.526E-01	.357E+00	.187E-01	.357E+00	.300E+01	.100E+01
.467E-01	.158E+02	.100E+01	.589E-01	.357E+00	.210E-01	.358E+00	.336E+01	.100E+01
.524E-01	.178E+02	.100E+01	.660E-01	.357E+00	.235E-01	.358E+00	.376E+01	.101E+01
.588E-01	.200E+02	.100E+01	.739E-01	.358E+00	.263E-01	.359E+00	.421E+01	.101E+01
.660E-01	.224E+02	.101E+01	.827E-01	.358E+00	.295E-01	.359E+00	.470E+01	.101E+01
.740E-01	.251E+02	.101E+01	.925E-01	.359E+00	.329E-01	.360E+00	.525E+01	.101E+01
.831E-01	.282E+02	.101E+01	.103E+00	.359E+00	.368E-01	.361E+00	.585E+01	.101E+01
.932E-01	.316E+02	.101E+01	.116E+00	.360E+00	.411E-01	.362E+00	.652E+01	.102E+01
.105E+00	.355E+02	.101E+01	.129E+00	.361E+00	.459E-01	.364E+00	.725E+01	.102E+01
.117E+00	.398E+02	.102E+01	.144E+00	.362E+00	.512E-01	.366E+00	.805E+01	.103E+01
.132E+00	.447E+02	.102E+01	.160E+00	.364E+00	.570E-01	.368E+00	.891E+01	.103E+01
.148E+00	.501E+02	.103E+01	.178E+00	.365E+00	.634E-01	.371E+00	.985E+01	.104E+01
.166E+00	.562E+02	.103E+01	.198E+00	.367E+00	.705E-01	.374E+00	.109E+02	.105E+01
.186E+00	.631E+02	.104E+01	.220E+00	.370E+00	.782E-01	.378E+00	.119E+02	.106E+01
.209E+00	.708E+02	.105E+01	.243E+00	.373E+00	.866E-01	.383E+00	.131E+02	.107E+01
.234E+00	.794E+02	.106E+01	.269E+00	.376E+00	.958E-01	.388E+00	.143E+02	.109E+01
.263E+00	.891E+02	.107E+01	.297E+00	.380E+00	.106E+00	.394E+00	.156E+02	.111E+01
.295E+00	.100E+03	.108E+01	.328E+00	.385E+00	.117E+00	.402E+00	.169E+02	.113E+01
.331E+00	.112E+03	.110E+01	.361E+00	.390E+00	.129E+00	.410E+00	.182E+02	.115E+01
.371E+00	.126E+03	.111E+01	.397E+00	.396E+00	.141E+00	.420E+00	.196E+02	.118E+01
.416E+00	.141E+03	.113E+01	.436E+00	.403E+00	.155E+00	.432E+00	.211E+02	.121E+01
.467E+00	.158E+03	.115E+01	.478E+00	.411E+00	.170E+00	.445E+00	.225E+02	.125E+01
.524E+00	.178E+03	.118E+01	.524E+00	.420E+00	.186E+00	.460E+00	.239E+02	.129E+01

.588E+00	.200E+03	.121E+01	.573E+00	.431E+00	.204E+00	.477E+00	.253E+02	.134E+01
.660E+00	.224E+03	.124E+01	.627E+00	.443E+00	.223E+00	.496E+00	.268E+02	.139E+01
.740E+00	.251E+03	.128E+01	.687E+00	.457E+00	.244E+00	.518E+00	.281E+02	.146E+01
.831E+00	.282E+03	.133E+01	.752E+00	.474E+00	.268E+00	.544E+00	.295E+02	.153E+01
.932E+00	.316E+03	.139E+01	.825E+00	.493E+00	.294E+00	.574E+00	.308E+02	.161E+01
.105E+01	.355E+03	.145E+01	.906E+00	.518E+00	.322E+00	.610E+00	.319E+02	.171E+01
.117E+01	.398E+03	.154E+01	.997E+00	.548E+00	.355E+00	.653E+00	.330E+02	.183E+01
.132E+01	.447E+03	.165E+01	.110E+01	.587E+00	.393E+00	.707E+00	.338E+02	.199E+01
.148E+01	.501E+03	.181E+01	.122E+01	.645E+00	.434E+00	.777E+00	.339E+02	.218E+01
.166E+01	.562E+03	.206E+01	.131E+01	.734E+00	.467E+00	.870E+00	.325E+02	.244E+01
.186E+01	.631E+03	.237E+01	.129E+01	.844E+00	.459E+00	.961E+00	.285E+02	.270E+01
.209E+01	.708E+03	.264E+01	.115E+01	.939E+00	.408E+00	.102E+01	.235E+02	.288E+01
.234E+01	.794E+03	.282E+01	.954E+00	.100E+01	.339E+00	.106E+01	.187E+02	.298E+01
.263E+01	.891E+03	.294E+01	.757E+00	.105E+01	.269E+00	.108E+01	.144E+02	.304E+01
.295E+01	.100E+04	.302E+01	.564E+00	.107E+01	.201E+00	.109E+01	.106E+02	.307E+01
.331E+01	.112E+04	.306E+01	.376E+00	.109E+01	.134E+00	.110E+01	.701E+01	.309E+01
.371E+01	.126E+04	.308E+01	.197E+00	.110E+01	.701E-01	.110E+01	.366E+01	.308E+01
.416E+01	.141E+04	.307E+01	.264E-01	.109E+01	.940E-02	.109E+01	.493E+00	.307E+01
.467E+01	.158E+04	.303E+01	-.134E+00	.108E+01	-.475E-01	.108E+01	-.252E+01	.304E+01
.524E+01	.178E+04	.298E+01	-.282E+00	.106E+01	-.100E+00	.107E+01	-.539E+01	.300E+01
.588E+01	.200E+04	.291E+01	-.416E+00	.104E+01	-.148E+00	.105E+01	-.813E+01	.294E+01
.660E+01	.224E+04	.283E+01	-.536E+00	.101E+01	-.191E+00	.103E+01	-.107E+02	.288E+01
.740E+01	.251E+04	.274E+01	-.642E+00	.974E+00	-.228E+00	.100E+01	-.132E+02	.281E+01
.831E+01	.282E+04	.263E+01	-.731E+00	.937E+00	-.260E+00	.973E+00	-.155E+02	.273E+01
.932E+01	.316E+04	.252E+01	-.806E+00	.898E+00	-.287E+00	.942E+00	-.177E+02	.265E+01
.105E+02	.355E+04	.241E+01	-.866E+00	.857E+00	-.308E+00	.911E+00	-.198E+02	.256E+01
.117E+02	.398E+04	.229E+01	-.911E+00	.815E+00	-.324E+00	.877E+00	-.217E+02	.246E+01
.132E+02	.447E+04	.217E+01	-.943E+00	.774E+00	-.336E+00	.843E+00	-.235E+02	.237E+01
.148E+02	.501E+04	.206E+01	-.963E+00	.733E+00	-.343E+00	.809E+00	-.251E+02	.227E+01
.166E+02	.562E+04	.195E+01	-.972E+00	.693E+00	-.346E+00	.774E+00	-.266E+02	.218E+01
.186E+02	.631E+04	.184E+01	-.972E+00	.654E+00	-.346E+00	.740E+00	-.279E+02	.208E+01
.209E+02	.708E+04	.173E+01	-.964E+00	.617E+00	-.343E+00	.706E+00	-.291E+02	.198E+01
.234E+02	.794E+04	.164E+01	-.949E+00	.582E+00	-.338E+00	.673E+00	-.301E+02	.189E+01
.263E+02	.891E+04	.154E+01	-.928E+00	.549E+00	-.330E+00	.641E+00	-.310E+02	.180E+01
.295E+02	.100E+05	.146E+01	-.903E+00	.518E+00	-.322E+00	.610E+00	-.318E+02	.171E+01
.331E+02	.112E+05	.137E+01	-.875E+00	.489E+00	-.312E+00	.580E+00	-.325E+02	.163E+01
.371E+02	.126E+05	.130E+01	-.845E+00	.462E+00	-.301E+00	.551E+00	-.331E+02	.155E+01
.416E+02	.141E+05	.123E+01	-.813E+00	.437E+00	-.289E+00	.524E+00	-.335E+02	.147E+01
.467E+02	.158E+05	.116E+01	-.779E+00	.414E+00	-.277E+00	.498E+00	-.338E+02	.140E+01
.524E+02	.178E+05	.110E+01	-.746E+00	.392E+00	-.265E+00	.474E+00	-.341E+02	.133E+01
.588E+02	.200E+05	.105E+01	-.712E+00	.372E+00	-.254E+00	.450E+00	-.343E+02	.127E+01
.660E+02	.224E+05	.994E+00	-.679E+00	.354E+00	-.242E+00	.428E+00	-.343E+02	.120E+01
.740E+02	.251E+05	.946E+00	-.646E+00	.337E+00	-.230E+00	.408E+00	-.343E+02	.115E+01
.831E+02	.282E+05	.901E+00	-.614E+00	.321E+00	-.219E+00	.388E+00	-.343E+02	.109E+01
.932E+02	.316E+05	.859E+00	-.583E+00	.306E+00	-.208E+00	.370E+00	-.342E+02	.104E+01
.105E+03	.355E+05	.820E+00	-.554E+00	.292E+00	-.197E+00	.352E+00	-.340E+02	.990E+00
.117E+03	.398E+05	.784E+00	-.525E+00	.279E+00	-.187E+00	.336E+00	-.338E+02	.944E+00
.132E+03	.447E+05	.751E+00	-.497E+00	.267E+00	-.177E+00	.321E+00	-.335E+02	.901E+00
.148E+03	.501E+05	.720E+00	-.471E+00	.256E+00	-.168E+00	.306E+00	-.332E+02	.860E+00
.166E+03	.562E+05	.690E+00	-.446E+00	.246E+00	-.159E+00	.293E+00	-.329E+02	.822E+00
.186E+03	.631E+05	.663E+00	-.422E+00	.236E+00	-.150E+00	.280E+00	-.325E+02	.786E+00
.209E+03	.708E+05	.637E+00	-.399E+00	.227E+00	-.142E+00	.268E+00	-.320E+02	.752E+00
.234E+03	.794E+05	.613E+00	-.377E+00	.218E+00	-.134E+00	.256E+00	-.316E+02	.720E+00
.263E+03	.891E+05	.591E+00	-.357E+00	.210E+00	-.127E+00	.246E+00	-.311E+02	.690E+00
.295E+03	.100E+06	.570E+00	-.337E+00	.203E+00	-.120E+00	.236E+00	-.306E+02	.662E+00

G. SAMPLE CASE 6a

This is the first of two calculations of the pressure coupled response function using the Denison and Baum technique. This case calculates the Denison and Baum A and B parameters for each of the individual pseudo-propellants based upon the Cohen postulates. Again, the oxidizer distribution is unimodal with a mean diameter of 40 microns and a mode width parameter equal to two. The oxidizer mass fraction is equal to .88 and all other default values are assumed.

```
$FLAG $
$PARMST $
$PROPDT $
$ALUMDT $
$EROSDT $
$RESPDT IRPDB=1 $
$OXDIST DBARI(1)=40., SIGMAI(1)=2.0, ALFAI(1)=.88, MODES=1 $
```

Figure 7. Data Deck for Sample Case Number 6a.

*** DENISON AND BAUM PRESSURE COUPLED RESPONSE CALCULATIONS ***

	DZERO (MICRONS)	RATE (CM/SEC)	A-DENISON AND BAUM	B-DENISON AND BAUM	PRESSURE EXPONENT	ITERA	R(P-PPERD) (CM/SEC)	R(P+PPERD) (CM/SEC)	ES1	ES2	AVV
1	3.042	3.3883	28.902364	.75559859	.6022720	2	3.3781	3.3985	0.00	0.00	0.00000
2	3.936	3.1912	24.066497	.73417072	.5578570	2	3.1823	3.2001	0.00	0.00	0.00000
3	5.093	2.9420	20.465801	.71391360	.4770325	2	2.9349	2.9490	0.00	0.00	0.00000
4	6.589	2.5937	18.147618	.69828943	.4398622	2	2.5879	2.5993	0.00	0.00	0.00000
5	8.525	2.3330	15.814670	.67944844	.4132841	2	2.3282	2.3378	0.00	0.00	0.00000
6	11.031	2.1096	13.732082	.65914000	.3910092	2	2.1055	2.1137	0.00	0.00	0.00000
7	14.272	1.9123	11.912665	.63772157	.3722498	2	1.9087	1.9158	0.00	0.00	0.00000
8	18.467	1.7347	10.341434	.61547234	.3574236	2	1.7316	1.7378	0.00	0.00	0.00000
9	23.893	1.5747	8.986031	.59249717	.3471377	2	1.5719	1.5774	0.00	0.00	0.00000
10	30.915	1.4316	7.810462	.56874404	.3415757	2	1.4292	1.4341	0.00	0.00	0.00000
11	40.000	1.3055	6.783586	.54407776	.3404021	2	1.3033	1.3077	0.00	0.00	0.00000
12	51.755	1.1959	5.881455	.51834427	.3431708	2	1.1939	1.1980	0.00	0.00	0.00000
13	66.964	1.1020	5.086424	.49140637	.3496416	2	1.1001	1.1040	0.00	0.00	0.00000
14	86.643	1.0229	4.386726	.46323245	.3596490	2	1.0210	1.0247	0.00	0.00	0.00000
15	112.104	.9570	3.771541	.43375814	.3727940	2	.9552	.9588	0.00	0.00	0.00000
16	145.048	.9026	3.235890	.40328752	.3883225	2	.9009	.9044	0.00	0.00	0.00000
17	187.674	.8572	2.775644	.37246547	.4052663	2	.8554	.8589	0.00	0.00	0.00000
18	242.825	.8176	2.386744	.34245392	.4226389	2	.8159	.8193	0.00	0.00	0.00000
19	314.184	.7805	2.061962	.31475249	.4385872	1	.7788	.7823	0.00	0.00	0.00000
20	406.513	.7441	1.797792	.29265136	.4451992	2	.7424	.7457	0.00	0.00	0.00000
21	525.975	.7115	1.568166	.27599601	.4187060	3	.7101	.7130	0.00	0.00	0.00000

NDF	OMEGA (CPS)	RE(RSP/N)	IM(RSP/N)	RE(RSP)	IM(RSP)	MAG(RSP)	PHASE (DEGREES)	MAG(RSP/N)
.295E-01	.100E+02	.100E+01	.490E-01	.356E+00	.175E-01	.357E+00	.280E+01	.100E+01
.331E-01	.112E+02	.100E+01	.550E-01	.357E+00	.196E-01	.357E+00	.314E+01	.100E+01
.371E-01	.126E+02	.100E+01	.617E-01	.357E+00	.219E-01	.357E+00	.352E+01	.100E+01
.416E-01	.141E+02	.100E+01	.691E-01	.357E+00	.246E-01	.358E+00	.394E+01	.100E+01
.467E-01	.158E+02	.100E+01	.775E-01	.357E+00	.276E-01	.358E+00	.442E+01	.101E+01
.524E-01	.178E+02	.100E+01	.869E-01	.357E+00	.309E-01	.359E+00	.494E+01	.101E+01
.588E-01	.200E+02	.100E+01	.973E-01	.358E+00	.346E-01	.359E+00	.553E+01	.101E+01
.660E-01	.224E+02	.101E+01	.109E+00	.358E+00	.388E-01	.360E+00	.619E+01	.101E+01
.740E-01	.251E+02	.101E+01	.122E+00	.359E+00	.435E-01	.361E+00	.691E+01	.101E+01
.831E-01	.282E+02	.101E+01	.137E+00	.359E+00	.487E-01	.363E+00	.771E+01	.102E+01
.932E-01	.316E+02	.101E+01	.153E+00	.360E+00	.544E-01	.364E+00	.860E+01	.102E+01
.105E+00	.355E+02	.101E+01	.171E+00	.361E+00	.609E-01	.366E+00	.957E+01	.103E+01
.117E+00	.398E+02	.102E+01	.191E+00	.362E+00	.680E-01	.369E+00	.106E+02	.104E+01
.132E+00	.447E+02	.102E+01	.214E+00	.364E+00	.760E-01	.372E+00	.118E+02	.104E+01
.148E+00	.501E+02	.103E+01	.238E+00	.366E+00	.848E-01	.375E+00	.131E+02	.105E+01
.166E+00	.562E+02	.103E+01	.266E+00	.368E+00	.946E-01	.380E+00	.144E+02	.107E+01
.186E+00	.631E+02	.104E+01	.296E+00	.370E+00	.105E+00	.385E+00	.159E+02	.108E+01
.209E+00	.708E+02	.105E+01	.330E+00	.374E+00	.117E+00	.392E+00	.175E+02	.110E+01
.234E+00	.794E+02	.106E+01	.367E+00	.377E+00	.131E+00	.399E+00	.191E+02	.112E+01
.263E+00	.891E+02	.107E+01	.408E+00	.382E+00	.145E+00	.409E+00	.208E+02	.115E+01
.295E+00	.100E+03	.109E+01	.453E+00	.388E+00	.161E+00	.420E+00	.226E+02	.118E+01
.331E+00	.112E+03	.111E+01	.503E+00	.394E+00	.179E+00	.433E+00	.244E+02	.122E+01
.371E+00	.126E+03	.113E+01	.558E+00	.402E+00	.199E+00	.449E+00	.263E+02	.126E+01
.416E+00	.141E+03	.116E+01	.617E+00	.412E+00	.220E+00	.467E+00	.281E+02	.131E+01
.467E+00	.158E+03	.119E+01	.682E+00	.424E+00	.243E+00	.488E+00	.298E+02	.137E+01
.524E+00	.178E+03	.123E+01	.752E+00	.438E+00	.268E+00	.513E+00	.315E+02	.144E+01

.588E+00	.200E+03	.128E+01	.828E+00	.455E+00	.295E+00	.542E+00	.329E+02	.152E+01
.660E+00	.224E+03	.134E+01	.907E+00	.476E+00	.323E+00	.575E+00	.342E+02	.162E+01
.740E+00	.251E+03	.141E+01	.991E+00	.500E+00	.353E+00	.612E+00	.352E+02	.172E+01
.831E+00	.282E+03	.149E+01	.108E+01	.530E+00	.383E+00	.654E+00	.359E+02	.184E+01
.932E+00	.316E+03	.159E+01	.116E+01	.564E+00	.414E+00	.700E+00	.363E+02	.197E+01
.105E+01	.355E+03	.170E+01	.125E+01	.605E+00	.444E+00	.750E+00	.363E+02	.211E+01
.117E+01	.398E+03	.183E+01	.133E+01	.651E+00	.472E+00	.804E+00	.360E+02	.226E+01
.132E+01	.447E+03	.197E+01	.140E+01	.703E+00	.498E+00	.861E+00	.353E+02	.242E+01
.148E+01	.501E+03	.214E+01	.146E+01	.761E+00	.519E+00	.922E+00	.343E+02	.259E+01
.166E+01	.562E+03	.232E+01	.150E+01	.825E+00	.535E+00	.984E+00	.330E+02	.276E+01
.186E+01	.631E+03	.251E+01	.153E+01	.895E+00	.544E+00	.105E+01	.313E+02	.294E+01
.209E+01	.708E+03	.272E+01	.153E+01	.968E+00	.544E+00	.111E+01	.294E+02	.312E+01
.234E+01	.794E+03	.293E+01	.150E+01	.104E+01	.535E+00	.117E+01	.271E+02	.329E+01
.263E+01	.891E+03	.315E+01	.145E+01	.112E+01	.516E+00	.123E+01	.247E+02	.346E+01
.295E+01	.100E+04	.336E+01	.136E+01	.120E+01	.485E+00	.129E+01	.220E+02	.363E+01
.331E+01	.112E+04	.356E+01	.124E+01	.127E+01	.442E+00	.134E+01	.192E+02	.377E+01
.371E+01	.126E+04	.376E+01	.109E+01	.134E+01	.388E+00	.139E+01	.162E+02	.391E+01
.416E+01	.141E+04	.393E+01	.906E+00	.140E+01	.323E+00	.143E+01	.130E+02	.403E+01
.467E+01	.158E+04	.407E+01	.695E+00	.145E+01	.247E+00	.147E+01	.970E+01	.413E+01
.524E+01	.178E+04	.418E+01	.462E+00	.149E+01	.165E+00	.150E+01	.632E+01	.420E+01
.588E+01	.200E+04	.425E+01	.206E+00	.151E+01	.734E-01	.152E+01	.278E+01	.426E+01
.660E+01	.224E+04	.428E+01	-.563E-01	.152E+01	-.200E-01	.152E+01	-.753E+00	.428E+01
.740E+01	.251E+04	.427E+01	-.328E+00	.152E+01	-.117E+00	.152E+01	-.439E+01	.428E+01
.831E+01	.282E+04	.423E+01	-.600E+00	.151E+01	-.213E+00	.152E+01	-.807E+01	.427E+01
.932E+01	.316E+04	.412E+01	-.852E+00	.147E+01	-.303E+00	.150E+01	-.117E+02	.421E+01
.105E+02	.355E+04	.399E+01	-.111E+01	.142E+01	-.395E+00	.147E+01	-.155E+02	.414E+01
.117E+02	.398E+04	.384E+01	-.132E+01	.137E+01	-.470E+00	.145E+01	-.190E+02	.406E+01
.132E+02	.447E+04	.361E+01	-.152E+01	.128E+01	-.540E+00	.139E+01	-.228E+02	.391E+01
.148E+02	.501E+04	.340E+01	-.171E+01	.121E+01	-.607E+00	.136E+01	-.266E+02	.381E+01
.166E+02	.562E+04	.317E+01	-.180E+01	.113E+01	-.640E+00	.130E+01	-.296E+02	.364E+01
.186E+02	.631E+04	.287E+01	-.193E+01	.102E+01	-.687E+00	.123E+01	-.339E+02	.346E+01
.209E+02	.708E+04	.266E+01	-.199E+01	.947E+00	-.708E+00	.118E+01	-.368E+02	.332E+01
.234E+02	.794E+04	.236E+01	-.198E+01	.839E+00	-.703E+00	.109E+01	-.400E+02	.308E+01
.263E+02	.891E+04	.210E+01	-.203E+01	.748E+00	-.724E+00	.104E+01	-.441E+02	.292E+01
.295E+02	.100E+05	.190E+01	-.194E+01	.677E+00	-.690E+00	.967E+00	-.456E+02	.272E+01
.331E+02	.112E+05	.161E+01	-.190E+01	.574E+00	-.676E+00	.887E+00	-.497E+02	.249E+01
.371E+02	.126E+05	.146E+01	-.186E+01	.521E+00	-.662E+00	.842E+00	-.518E+02	.237E+01
.416E+02	.141E+05	.123E+01	-.170E+01	.439E+00	-.604E+00	.746E+00	-.540E+02	.210E+01
.467E+02	.158E+05	.107E+01	-.165E+01	.380E+00	-.588E+00	.700E+00	-.571E+02	.197E+01
.524E+02	.178E+05	.967E+00	-.149E+01	.344E+00	-.529E+00	.631E+00	-.570E+02	.177E+01
.588E+02	.200E+05	.789E+00	-.140E+01	.281E+00	-.500E+00	.573E+00	-.607E+02	.161E+01
.660E+02	.224E+05	.744E+00	-.126E+01	.265E+00	-.450E+00	.522E+00	-.595E+02	.147E+01
.740E+02	.251E+05	.612E+00	-.117E+01	.218E+00	-.417E+00	.470E+00	-.624E+02	.132E+01
.831E+02	.282E+05	.602E+00	-.105E+01	.214E+00	-.375E+00	.432E+00	-.603E+02	.121E+01
.932E+02	.316E+05	.506E+00	-.983E+00	.180E+00	-.350E+00	.393E+00	-.628E+02	.111E+01
.105E+03	.355E+05	.454E+00	-.919E+00	.162E+00	-.327E+00	.365E+00	-.637E+02	.103E+01
.117E+03	.398E+05	.425E+00	-.848E+00	.151E+00	-.302E+00	.338E+00	-.634E+02	.949E+00
.132E+03	.447E+05	.379E+00	-.755E+00	.135E+00	-.269E+00	.301E+00	-.633E+02	.845E+00
.148E+03	.501E+05	.330E+00	-.704E+00	.118E+00	-.251E+00	.277E+00	-.649E+02	.778E+00
.166E+03	.562E+05	.281E+00	-.630E+00	.999E-01	-.224E+00	.246E+00	-.660E+02	.690E+00
.186E+03	.631E+05	.267E+00	-.560E+00	.951E-01	-.200E+00	.221E+00	-.645E+02	.621E+00
.209E+03	.708E+05	.255E+00	-.506E+00	.907E-01	-.180E+00	.202E+00	-.633E+02	.567E+00
.234E+03	.794E+05	.243E+00	-.460E+00	.866E-01	-.164E+00	.185E+00	-.622E+02	.521E+00
.263E+03	.891E+05	.232E+00	-.421E+00	.825E-01	-.150E+00	.171E+00	-.611E+02	.480E+00
.295E+03	.100E+06	.221E+00	-.385E+00	.786E-01	-.137E+00	.158E+00	-.602E+02	.444E+00

H. SAMPLE CASE 6b

This is the second of two calculations of the pressure coupled response function using the Denison and Baum technique. This case determines the Denison and Baum A and B parameters for each of the individual pseudo-propellants in the manner originally proposed, that is, not subjected to the Cohen postulates. Again, the oxidizer distribution is unimodal with a mean diameter of 40 microns and a mode width parameter equal to two. The oxidizer mass fraction is equal to .88 and all other default values are assumed.

```
$FLAG $
$PARMST $
$PROPDT $
$ALUMDT $
$EROSDT $
$RESPDT IRPDB=2 $
$OXDIST DBARI(1)=40., SIGMAI(1)=2.0, ALFAI(1)=.88, MODES=1 $
```

Figure 8. Data Deck for Sample Case Number 6b.

*** DENISON AND BAUM PRESSURE COUPLED RESPONSE CALCULATIONS ***

	DZERO (MICRONS)	RATE (CM/SEC)	A-DENISON AND BAUM	B-DENISON AND BAUM	PRESSURE EXPONENT	ITERA	R(P-PPERD) (CM/SEC)	R(P+PPERD) (CM/SEC)	ES1	ES2	AVV
1	3.042	3.3883	8.819899	2.04689041	.6022720	0	3.3781	3.3985	27728.15	26845.47	8.53913
2	3.936	3.1912	8.883749	2.03918378	.5578570	0	3.1823	3.2001	27839.76	26709.52	8.52309
3	5.093	2.9420	9.006970	4.15759937	.4770325	0	2.9349	2.9490	28102.45	26551.02	8.50973
4	6.589	2.5937	9.123500	2.12458270	.4398822	0	2.5879	2.5993	28270.07	26367.98	8.50965
5	8.525	2.3330	9.249960	1.43166699	.4132841	0	2.3282	2.3378	28501.29	26172.55	8.49418
6	11.031	2.1096	9.398352	1.16672829	.3910092	0	2.1055	2.1137	28808.07	25958.05	8.46856
7	14.272	1.9123	9.574837	1.03928483	.3722498	0	1.9087	1.9158	29203.90	25720.43	8.43274
8	18.467	1.7347	9.782036	.96233086	.3574236	0	1.7316	1.7378	29693.12	25455.75	8.38609
9	23.893	1.5747	10.019331	.90604153	.3471377	0	1.5719	1.5774	30272.73	25159.43	8.32699
10	30.915	1.4316	10.285642	.85359152	.3415757	0	1.4292	1.4341	30940.52	24825.44	8.25279
11	40.000	1.3055	10.583362	.80158353	.3404021	0	1.3033	1.3077	31705.99	24445.08	8.15969
12	51.755	1.1959	10.919659	.74945453	.3431708	0	1.1939	1.1980	32593.64	24006.03	8.04260
13	66.964	1.1020	11.306160	.69803638	.3496416	0	1.1001	1.1040	33641.73	23490.76	7.89467
14	86.643	1.0229	11.762695	.64831089	.3596490	0	1.0210	1.0247	34913.66	22874.44	7.70658
15	112.104	.9570	12.327776	.60428866	.3727940	0	.9552	.9588	36529.13	22122.63	7.46590
16	145.048	.9026	13.074593	.56655628	.3883225	0	.9009	.9044	38711.75	21190.00	7.15676
17	187.674	.8572	14.128752	.53772099	.4052663	0	.8554	.8589	41842.78	20024.32	6.76147
18	242.825	.8176	15.652664	.51907706	.4226389	0	.8159	.8193	46418.29	18589.80	6.26865
19	314.184	.7805	17.544094	.51071629	.4385872	0	.7788	.7823	52157.43	16960.01	5.70481
20	406.513	.7441	17.862595	.50724536	.4451992	0	.7424	.7457	53288.05	15635.39	5.24111
21	525.975	.7115	12.884630	.48464797	.4187060	0	.7101	.7130	38568.85	16220.71	5.41882

NDF	OMEGA (CPS)	RE(RSP/N)	IM(RSP/N)	RE(RSP)	IM(RSP)	MAG(RSP)	PHASE (DEGREES)	MAG(RSP/N)
.295E-01	.100E+02	.100E+01	.373E-01	.356E+00	.133E-01	.357E+00	.214E+01	.100E+01
.331E-01	.112E+02	.100E+01	.419E-01	.356E+00	.149E-01	.357E+00	.239E+01	.100E+01
.371E-01	.126E+02	.100E+01	.469E-01	.357E+00	.167E-01	.357E+00	.268E+01	.100E+01
.416E-01	.141E+02	.100E+01	.526E-01	.357E+00	.187E-01	.357E+00	.300E+01	.100E+01
.467E-01	.158E+02	.100E+01	.589E-01	.357E+00	.210E-01	.358E+00	.336E+01	.100E+01
.524E-01	.178E+02	.100E+01	.660E-01	.357E+00	.235E-01	.358E+00	.376E+01	.101E+01
.588E-01	.200E+02	.100E+01	.739E-01	.358E+00	.263E-01	.359E+00	.421E+01	.101E+01
.660E-01	.224E+02	.101E+01	.827E-01	.358E+00	.295E-01	.359E+00	.470E+01	.101E+01
.740E-01	.251E+02	.101E+01	.926E-01	.358E+00	.329E-01	.360E+00	.525E+01	.101E+01
.831E-01	.282E+02	.101E+01	.103E+00	.359E+00	.368E-01	.361E+00	.586E+01	.101E+01
.932E-01	.316E+02	.101E+01	.116E+00	.360E+00	.411E-01	.362E+00	.653E+01	.102E+01
.105E+00	.355E+02	.101E+01	.129E+00	.361E+00	.459E-01	.363E+00	.726E+01	.102E+01
.117E+00	.398E+02	.102E+01	.144E+00	.362E+00	.512E-01	.365E+00	.806E+01	.103E+01
.132E+00	.447E+02	.102E+01	.160E+00	.363E+00	.570E-01	.367E+00	.893E+01	.103E+01
.148E+00	.501E+02	.102E+01	.178E+00	.364E+00	.634E-01	.370E+00	.988E+01	.104E+01
.166E+00	.562E+02	.103E+01	.198E+00	.366E+00	.705E-01	.373E+00	.109E+02	.105E+01
.186E+00	.631E+02	.103E+01	.220E+00	.368E+00	.782E-01	.377E+00	.120E+02	.106E+01
.209E+00	.708E+02	.104E+01	.243E+00	.371E+00	.866E-01	.381E+00	.131E+02	.107E+01
.234E+00	.794E+02	.105E+01	.269E+00	.374E+00	.958E-01	.386E+00	.144E+02	.108E+01
.263E+00	.891E+02	.106E+01	.297E+00	.377E+00	.106E+00	.392E+00	.157E+02	.110E+01
.295E+00	.100E+03	.107E+01	.328E+00	.381E+00	.117E+00	.398E+00	.170E+02	.112E+01
.331E+00	.112E+03	.108E+01	.360E+00	.385E+00	.128E+00	.406E+00	.184E+02	.114E+01
.371E+00	.126E+03	.110E+01	.396E+00	.390E+00	.141E+00	.415E+00	.199E+02	.117E+01
.416E+00	.141E+03	.111E+01	.434E+00	.396E+00	.155E+00	.425E+00	.213E+02	.119E+01
.467E+00	.158E+03	.113E+01	.476E+00	.402E+00	.169E+00	.436E+00	.228E+02	.123E+01
.524E+00	.178E+03	.115E+01	.520E+00	.409E+00	.185E+00	.449E+00	.244E+02	.126E+01

.588E+00	.200E+03	.117E+01	.568E+00	.417E+00	.202E+00	.463E+00	.259E+02	.130E+01
.660E+00	.224E+03	.119E+01	.619E+00	.425E+00	.220E+00	.479E+00	.274E+02	.135E+01
.740E+00	.251E+03	.122E+01	.674E+00	.435E+00	.240E+00	.497E+00	.289E+02	.139E+01
.831E+00	.282E+03	.125E+01	.733E+00	.445E+00	.261E+00	.516E+00	.304E+02	.145E+01
.932E+00	.316E+03	.128E+01	.796E+00	.456E+00	.284E+00	.537E+00	.318E+02	.151E+01
.105E+01	.355E+03	.132E+01	.864E+00	.469E+00	.308E+00	.561E+00	.333E+02	.158E+01
.117E+01	.398E+03	.136E+01	.937E+00	.483E+00	.334E+00	.587E+00	.346E+02	.165E+01
.132E+01	.447E+03	.140E+01	.102E+01	.498E+00	.362E+00	.616E+00	.360E+02	.173E+01
.148E+01	.501E+03	.145E+01	.110E+01	.515E+00	.392E+00	.647E+00	.372E+02	.182E+01
.166E+01	.562E+03	.150E+01	.119E+01	.534E+00	.424E+00	.682E+00	.384E+02	.192E+01
.186E+01	.631E+03	.156E+01	.129E+01	.556E+00	.459E+00	.721E+00	.395E+02	.203E+01
.209E+01	.708E+03	.163E+01	.140E+01	.580E+00	.497E+00	.764E+00	.406E+02	.215E+01
.234E+01	.794E+03	.171E+01	.151E+01	.608E+00	.538E+00	.812E+00	.415E+02	.228E+01
.263E+01	.891E+03	.180E+01	.164E+01	.640E+00	.583E+00	.866E+00	.423E+02	.243E+01
.295E+01	.100E+04	.190E+01	.178E+01	.677E+00	.632E+00	.926E+00	.430E+02	.260E+01
.331E+01	.112E+04	.202E+01	.193E+01	.721E+00	.687E+00	.996E+00	.436E+02	.280E+01
.371E+01	.126E+04	.217E+01	.210E+01	.773E+00	.747E+00	.108E+01	.440E+02	.302E+01
.416E+01	.141E+04	.235E+01	.229E+01	.836E+00	.815E+00	.117E+01	.443E+02	.328E+01
.467E+01	.158E+04	.256E+01	.250E+01	.911E+00	.891E+00	.127E+01	.444E+02	.358E+01
.524E+01	.178E+04	.360E+01	-.781E+00	.128E+01	-.278E+00	.131E+01	-.122E+02	.369E+01
.588E+01	.200E+04	.344E+01	-.950E+00	.122E+01	-.338E+00	.127E+01	-.154E+02	.357E+01
.660E+01	.224E+04	.332E+01	-.108E+01	.118E+01	-.383E+00	.124E+01	-.180E+02	.349E+01
.740E+01	.251E+04	.318E+01	-.118E+01	.113E+01	-.420E+00	.121E+01	-.204E+02	.339E+01
.831E+01	.282E+04	.304E+01	-.127E+01	.108E+01	-.451E+00	.117E+01	-.227E+02	.329E+01
.932E+01	.316E+04	.289E+01	-.134E+01	.103E+01	-.475E+00	.113E+01	-.248E+02	.318E+01
.105E+02	.355E+04	.273E+01	-.138E+01	.972E+00	-.493E+00	.109E+01	-.269E+02	.306E+01
.117E+02	.398E+04	.258E+01	-.142E+01	.917E+00	-.505E+00	.105E+01	-.288E+02	.294E+01
.132E+02	.447E+04	.242E+01	-.143E+01	.862E+00	-.510E+00	.100E+01	-.306E+02	.281E+01
.148E+02	.501E+04	.227E+01	-.144E+01	.808E+00	-.511E+00	.956E+00	-.323E+02	.269E+01
.166E+02	.562E+04	.212E+01	-.143E+01	.756E+00	-.507E+00	.911E+00	-.339E+02	.256E+01
.186E+02	.631E+04	.198E+01	-.140E+01	.707E+00	-.500E+00	.866E+00	-.353E+02	.243E+01
.209E+02	.708E+04	.185E+01	-.137E+01	.659E+00	-.489E+00	.821E+00	-.366E+02	.231E+01
.234E+02	.794E+04	.173E+01	-.134E+01	.615E+00	-.476E+00	.777E+00	-.378E+02	.218E+01
.263E+02	.891E+04	.161E+01	-.129E+01	.573E+00	-.461E+00	.735E+00	-.388E+02	.206E+01
.295E+02	.100E+05	.150E+01	-.125E+01	.534E+00	-.444E+00	.694E+00	-.398E+02	.195E+01
.331E+02	.112E+05	.140E+01	-.120E+01	.497E+00	-.426E+00	.655E+00	-.406E+02	.184E+01
.371E+02	.126E+05	.130E+01	-.115E+01	.464E+00	-.408E+00	.618E+00	-.414E+02	.174E+01
.416E+02	.141E+05	.121E+01	-.109E+01	.432E+00	-.390E+00	.582E+00	-.420E+02	.163E+01
.467E+02	.158E+05	.113E+01	-.104E+01	.404E+00	-.371E+00	.548E+00	-.426E+02	.154E+01
.524E+02	.178E+05	.106E+01	-.990E+00	.377E+00	-.353E+00	.516E+00	-.431E+02	.145E+01
.588E+02	.200E+05	.990E+00	-.940E+00	.352E+00	-.335E+00	.486E+00	-.435E+02	.137E+01
.660E+02	.224E+05	.927E+00	-.891E+00	.330E+00	-.317E+00	.457E+00	-.439E+02	.129E+01
.740E+02	.251E+05	.868E+00	-.843E+00	.309E+00	-.300E+00	.431E+00	-.442E+02	.121E+01
.831E+02	.282E+05	.813E+00	-.797E+00	.289E+00	-.284E+00	.405E+00	-.444E+02	.114E+01
.932E+02	.316E+05	.763E+00	-.753E+00	.272E+00	-.268E+00	.382E+00	-.446E+02	.107E+01
.105E+03	.355E+05	.716E+00	-.711E+00	.255E+00	-.253E+00	.359E+00	-.448E+02	.101E+01
.117E+03	.398E+05	.672E+00	-.672E+00	.239E+00	-.239E+00	.338E+00	-.450E+02	.950E+00
.132E+03	.447E+05	.632E+00	-.634E+00	.225E+00	-.226E+00	.319E+00	-.451E+02	.895E+00
.148E+03	.501E+05	.594E+00	-.598E+00	.212E+00	-.213E+00	.300E+00	-.452E+02	.843E+00
.166E+03	.562E+05	.559E+00	-.564E+00	.199E+00	-.201E+00	.283E+00	-.452E+02	.794E+00
.186E+03	.631E+05	.527E+00	-.532E+00	.187E+00	-.189E+00	.266E+00	-.453E+02	.748E+00
.209E+03	.708E+05	.496E+00	-.501E+00	.177E+00	-.178E+00	.251E+00	-.453E+02	.705E+00
.234E+03	.794E+05	.467E+00	-.473E+00	.166E+00	-.168E+00	.237E+00	-.453E+02	.665E+00
.263E+03	.891E+05	.441E+00	-.445E+00	.157E+00	-.159E+00	.223E+00	-.453E+02	.627E+00
.295E+03	.100E+06	.415E+00	-.420E+00	.148E+00	-.150E+00	.210E+00	-.453E+02	.591E+00

I. SAMPLE CASE 7

This case is the first of the nonsteady state velocity coupled response calculations. The method employed in this case is the small perturbation technique. However, in this case and in the next two cases, the oxidizer distribution is unimodal with a mean diameter of 40 microns and a mode width parameter equal to one. That is, only one size oxidizer particles are assumed. The reason for the monodisperse consideration is due to the tremendous computational time required by the erosive burning technique. The oxidizer mass fraction is again assumed to be equal to .88 and the other default parameters values are assumed. Since the velocity coupled response model is based upon a perturbation of the erosive burning model equations, a value of crossflow velocity must be specified. In this and the next two cases, the crossflow velocity is assumed to be 20000 centimeters per sec. As was the case for the pressure coupled response function output, the same velocity coupled response function versus frequency results are presented for these three cases.

```
$FLAG $
$PARMST $
$PROPDT $
$ALUMDT $
$EROSDT UINF=20000. $
$RESPDT IRVHM=1 $
$OXDIST DBARI(1)=40., SIGMAI(1)=1.0, ALFAI(1)=.88, MODES=1 $
```

Figure 9. Data Deck for Sample Case Number 7.

***** PETITE ENSEMBLE MODEL(PEM) INPUT/OUTPUT PARAMETERS *****

TZERO-INITIAL SOLID PROPELLANT TEMPERATURE	294.15	KELVIN			
XALFA-OXIDIZER TOTAL MASS FRACTION	.8800		NPROP-PROPELLANT NUMBER	0	
AOXID-OXIDIZER TYPE	AP		AFUEL-FUEL BINDER TYPE	HTPB	
QL-OXIDIZER HEAT OF DECOMPOSITION	0.00	CAL/GRAM	QFUEL-FUEL HEAT OF PYROLYSIS	433.00	CAL/GRAM
RHOX-OXIDIZER DENSITY	1.950	G/CM**3	RHOF-FUEL DENSITY	.920	G/CM**3
AOX-OXIDIZER DECOMPOSITION FREQ. FACTOR	.166E+05	G/CM**2-S	AF-FUEL PYROLYSIS FREQUENCY FACTOR	.299E+03	G/CM**2-S
EOX-OXIDIZER DECOMPOSITION ACTIV. ENERGY	21000.	CAL/MOLE	EF-FUEL PYROLYSIS ACTIVATION ENERGY	16900.	CAL/MOLE
AAP-OXIDIZER FLAME FREQUENCY FACTOR	2500000.	CM3-G/S-A	APF-PRIMARY FLAME FREQUENCY FACTOR	1400.	CM3-G/S-A
EAP-OXIDIZER FLAME ACTIVATION ENERGY	25000.	CAL/MOLE	EPF-PRIMARY FLAME ACTIVATION ENERGY	15000.	CAL/MOLE
DELAP-OXIDIZER FLAME REACTION ORDER	1.0		DELPF-PRIMARY FLAME REACTION ORDER	1.5	
PFMW-PRIMARY FLAME M.W. (1000 PSIA)	25.99	G/GMOLE	XNUPF-PRIMARY FLAME STOICHIOMETRY VARIABLE	9.30	
FFMW-FINAL FLAME M.W. (1000 PSIA)	26.95	G/GMOLE	XNUFF-FINAL FLAME STOICHIOMETRY VARIABLE	9.30	
CP-GAS PHASE SPECIFIC HEAT CAPACITY	.40	CAL/G-K	CIGN-IGNITION DELAY PROPORTIONALITY VALUE	190.	S-ATM/CM
XLAMB-GAS PHASE THERMAL CONDUCTIVITY	.50000E-05	CAL/CM-S-K	POWD-IGNITION DELAY DIAMETER EXPONENT	.800	
GAMMA-DIFFUSION COEFFICIENT PARAMETER	.760E-05	CM2-A/S-K	POWIG-IGNITION DELAY PRESSURE EXPONENT	.721	
PLAMB-SOLID PHASE THERMAL CONDUCTIVITY	.00030	CAL/CM-S-K	CS-SOLID PHASE SPECIFIC HEAT	.20	
FACTOR-FLAME TEMPERATURE PARAMETER	.50				

PSTART-STARTING PRESSURE (RATE/PRESSURE)	68.0272	ATMS	LIMBES-NUMBER OF TERMS (BURKE SCHUMANN)	40	
PSTOP-STOPPING PRESSURE (RATE/PRESSURE)	68.0272	ATMS	ERRBES-MINIMUM VALUE OF LAST TERM IN SERIES	.100E-06	
NPRESS-NUMBER OF PRESSURES CONSIDERED	1		ESTART-INITIAL N.D. DIFFUSION HEIGHT	.100E+00	
NDPM-NUMBER OF DIAMETERS/MODE-(RATE CAL.)	21		XHUHI-MAX VOLUME FRACTION (BURKE SCHUMANN)	.980	
NXDPM-NUMBER OF DIAMETERS/MODE-(C-CAL.)	201		XHULOW-MIN VOLUME FRACTION (BURKE SCHUMANN)	.300	
UINF-CROSS FLOW VELOCITY-EROSIVE BURNING	20000.	CM/SEC	CPRIME-CONSTANT IN PRANDTL MIXING LENGTH EXP.	.16	
YSTART-STARTING VALUE OF Y-COORDINATE(CM)	0.000000		COND-PROP. CONST.-DIFFUSION COEFFICIENT	1.00	
YSTOP-STOPPING VALUE OF Y-COORDINATE(CM)	1.000000		CONC-PROP. CONST.-THERMAL CONDUCTIVITY	1.00	
NSTEP-NUMBER OF STEPS-TURB. VEL. PROFILE	461		ITERO-NUMBER OF EROSIVE BURNING ITERATIONS	20	
INSTEP-STEPS/UNIT LN10(Y-COORDINATE)	100		NCYC-NUMBER OF LOG10 CYCLES USED	5	

PPERD-PRESSURE PERTURBATION (NONSTEADY)	.50	PERCENT	***** METAL PARAMETERS *****		
TPERD-TEMPERATURE PERTURBATION (NONSTEADY)	.50	PERCENT	ALTYPE-ALUMINUM TYPE	NONE	
BFAC-COHEN POSTULATE CONSTANT (MAGNITUDE)	1360.000	MICRON	BETA-MASS FRACTION OF METAL	0.0000	
FFAC-COHEN POSTULATE CONSTANT (FREQUENCY)	4.720		QM-LATENT HEAT OF METAL LIQUIFACTION	96.00	CAL/GRAM
OSTART-STARTING FREQUENCY (NONS. RESPONSE)	10.	HERTZ	RHOM-METAL DENSITY	2.710	G/CM**3
OSTOP-STOPPING FREQUENCY (NONS. RESPONSE)	100000.	HERTZ	DBARM-MEAN DIAMETER OF METAL DISTRIBUTION	6.000	MICRON
NOMEG-NUMBER OF FREQUENCIES CONSIDERED	81		SIGMAM-WIDTH PARAMETER OF METAL DISTRIBUTION	1.0000	

***** CATALYST PARAMETERS *****			***** ADDITIVE PARAMETERS *****		
CATYPE-CATALYST TYPE	NONE				
ALFCAT-MASS FRACTION OF CATALYST	0.0000		ADTYPE-ADDITIVE 1 TYPE	NONE	
SPSUR-SPECIFIC SURFACE OF CATALYST	0.0000	M**2/GRAM	ALFADD-ADDITIVE 1 MASS FRACTION	0.0000	
CAP-AP FLAME FACTOR (EXPONENTIAL)	0.00				
EAP2-AP FLAME FACTOR (ACT. ENERGY)	0.00	CAL/MOLE	ADTYPE-ADDITIVE 2 TYPE	NONE	
CPF-PF FLAME FACTOR (EXPONENTIAL)	14.96		ALFADD-ADDITIVE 2 MASS FRACTION	0.0000	
EPF2-PF FLAME FACTOR (ACT. ENERGY)	2610.00	CAL/MOLE			

XNUT-OXIDIZER VOLUME FRACTION	.77578		CX-VALUE OF C IN VF=C*DZERO**N EXPRESS.	.151E+00	
RHOT-TOTAL PROPELLANT DENSITY	1.71905	G/CM**3	XN-VALUE OF N IN VF=C*DZERO**N EXPRESS.	3.000	
RHOFA-FUEL-ALUMINUM MIXTURE DENSITY	.92000	G/CM**3	MODES-NUMBER OF OXIDIZER MODES	1	

MODE NUMBER	MEAN DIAMETER (DBARI)	MODE WIDTH PARAMETER (SIGMAI)	MASS FRACTION (ALFAI)	MASS FRACTION (CORR)
1	40.000	1.0000	.8800	

PRESSURE IS 1000.0 PSIA   THE OXID/FUEL BEING CONSIDERED IS   AP/ HTPB
INITIAL PROPELLANT TEMPERATURE IS 294.2 DEGREES KELVIN

DZERO (MICRONS)	BETAF	XSTPD (MICRONS)	XSTPF (MICRONS)	XSTAP (MICRONS)	XSTFD (MICRONS)	TF (K)	TS (K)	TSPF ...	TSFF (PERCENT)	TSAP ...	TSQL (K)	TSQF (K)	TSQM (K)	SOXP
40.00	.028	24.207	.354	1.029	23.138	2998.3	1107.14	9.62	23.78	66.61	0.00	-295.23	0.00	2.145

DZERO (MICRONS)	RATE (CM/SEC)	XNUU	ALFAU	RHOU (G/CM**3)	FSKP	XLAMAP (CAL/CM-S-K)	XLAMPF (CAL/CM-S-K)	XLAMFF (CAL/CM-S-K)
40.00	1.3055	.7758	.8800	1.7190	0.0000	.1772E-03	.2265E-03	.2265E-03

MODE NUMBER 1   SERIES RATE = 1.3055 CM/SEC   PARALLEL RATE = 1.3055 CM/SEC   BETAR = .3055

THE CONVERGENCE ON THE EROSIVE BURNING RATE FOLLOWS

1   1   1.82567   1.30552   BOUNDARY LAYER THICKNESS = 4000.00 MICRONS
TAUBL = 2052.7   XMEW = .90614E-03 GRAMS/CM-SEC   AMWBL = 26.4695

***** EROSIVE BURNING OUTPUT *****

FREE STREAM VELOCITY	20000.0 CM/SEC	FREE STREAM GAS PRESSURE	68.027 ATMS
BOUND.LAYER TEMPERATURE	2052.7 KELVIN	BOUND.LAYER GAS DENSITY	.10690E-01 GRAMS/CM**3
MOLECULAR VISCOSITY	.90614E-03 GRAMS/CM-S	PIPE HYDRAULIC DIAM.	2.00 CM
REYNOLDS NUMBER	.47190E+06	BLOWING PARAMETER, B	.43493E+01
COEFFICIENT OF FRICTION (B=0)	.48268E-02	WALL SHEAR STRESS	.58731E+03 DYNE/CM**2
COEFFICIENT OF FRICTION	.27469E-03	INITIAL PROPELLANT TEMP	294.15 KELVIN
AVERAGE ROUGHNESS HEIGHT	.001584 CM	CF/CFZERO EXPRESSION (IBLOW)	4

DZERO (MIC)	ROUGH (MIC)	XSTPD (MIC)	XSTPF (MIC)	XSTAP (MIC)	XSTFD (MIC)	XLAMAP ...	XLAMPF (CAL/CM-S-K)	XLAMFF ...	GAMAPF (CM2/S)	GAMAFF (CM2/S)
40.000	16.391	18.9188	.4955	1.4387	17.7210	.180E-03	.230E-03	.508E-03	.157E+00	.196E+00

DZERO (MIC)	R-EROS (CM/S)	R-NEROS (CM/S)	EBETA	BETAF	TS (K)	TSB (K)	TSPF ...	TSFF (PERCENT)	TSAP ...	TSBN (K)
40.000	1.8257	1.3055	.3984	.0499	1141.88	1141.88	12.94	49.03	38.03	-115.60

```
1    2  1.77123     1.56560     BOUNDARY LAYER THICKNESS = 3300.00 MICRONS
                                TAVBL = 2070.1   XMEW =  .90997E-03 GRAMS/CM-SEC   AMWBL =    26.4695
```

***** EROSIVE BURNING OUTPUT *****

FREE STREAM VELOCITY	20000.0 CM/SEC	FREE STREAM GAS PRESSURE	68.027 ATMS
BOUND.LAYER TEMPERATURE	2070.1 KELVIN	BOUND.LAYER GAS DENSITY	.10601E-01 GRAMS/CM**3
MOLECULAR VISCOSITY	.90997E-03 GRAMS/CM-S	PIPE HYDRAULIC DIAM.	2.00 CM
REYNOLDS NUMBER	.46598E+06	BLOWING PARAMETER, B	.52212E+01
COEFFICIENT OF FRICTION (B=0)	.48626E-02	WALL SHEAR STRESS	.29228E+03 DYNE/CM**2
COEFFICIENT OF FRICTION	.13786E-03	INITIAL PROPELLANT TEMP	294.15 KELVIN
AVERAGE ROUGHNESS HEIGHT	.001639 CM	CF/CFZERO EXPRESSION (IBLOW)	4

DZERO (MIC)	ROUGH (MIC)	XSTPD (MIC)	XSTPF (MIC)	XSTAP (MIC)	XSTFD (MIC)	XLAMAP ...	XLAMPF (CAL/CM-S-K)	XLAMFF ...	GAMAPF (CM2/S)	GAMAFF (CM2/S)
40.000	16.344	19.2106	.4807	1.3958	18.0519	.179E-03	.229E-03	.477E-03	.147E+00	.181E+00

DZERO (MIC)	R-EROS (CM/S)	R-NEROS (CM/S)	EBETA	BETAF	TS (K)	TSB (K)	TSPF ...	TSFF (PERCENT)	TSAP ...	TSBN (K)
40.000	1.7712	1.3055	.3567	.0476	1138.62	1138.62	12.75	46.83	40.42	-115.16

```
1    3  1.74357     1.73563     BOUNDARY LAYER THICKNESS = 2900.00 MICRONS
                                TAVBL = 2068.5   XMEW =  .90961E-03 GRAMS/CM-SEC   AMWBL =    26.4695
```

***** EROSIVE BURNING OUTPUT *****

FREE STREAM VELOCITY	20000.0 CM/SEC	FREE STREAM GAS PRESSURE	68.027 ATMS
BOUND.LAYER TEMPERATURE	2068.5 KELVIN	BOUND.LAYER GAS DENSITY	.10609E-01 GRAMS/CM**3
MOLECULAR VISCOSITY	.90961E-03 GRAMS/CM-S	PIPE HYDRAULIC DIAM.	2.00 CM
REYNOLDS NUMBER	.46653E+06	BLOWING PARAMETER, B	.57874E+01
COEFFICIENT OF FRICTION (B=0)	.48595E-02	WALL SHEAR STRESS	.18352E+03 DYNE/CM**2
COEFFICIENT OF FRICTION	.86494E-04	INITIAL PROPELLANT TEMP	294.15 KELVIN
AVERAGE ROUGHNESS HEIGHT	.001634 CM	CF/CFZERO EXPRESSION (IBLOW)	4

DZERO (MIC)	ROUGH (MIC)	XSTPD (MIC)	XSTPF (MIC)	XSTAP (MIC)	XSTFD (MIC)	XLAMAP ...	XLAMPF (CAL/CM-S-K)	XLAMFF ...	GAMAPF (CM2/S)	GAMAFF (CM2/S)
40.000	16.319	19.3751	.4732	1.3740	18.2342	.179E-03	.228E-03	.461E-03	.142E+00	.173E+00

DZERO (MIC)	R-EROS (CM/S)	R-NEROS (CM/S)	EBETA	BETAF	TS (K)	TSB (K)	TSPF ...	TSFF (PERCENT)	TSAP ...	TSBN (K)
40.000	1.7436	1.3055	.3355	.0465	1136.94	1136.94	12.64	45.66	41.70	-114.93

1 4 1.74271 1.74246 BOUNDARY LAYER THICKNESS = 2900.00 MICRONS
TAVBL = 2067.6 XMEW = .90943E-03 GRAMS/CM-SEC AMWBL = 26.4695

***** EROSIVE BURNING OUTPUT *****

FREE STREAM VELOCITY	20000.0 CM/SEC	FREE STREAM GAS PRESSURE	68.027 ATMS
BOUND.LAYER TEMPERATURE	2067.6 KELVIN	BOUND.LAYER GAS DENSITY	.10613E-01 GRAMS/CM**3
MOLECULAR VISCOSITY	.90943E-03 GRAMS/CM-S	PIPE HYDRAULIC DIAM.	2.00 CM
REYNOLDS NUMBER	.46681E+06	BLOWING PARAMETER, B	.58097E+01
COEFFICIENT OF FRICTION (B=0)	.48579E-02	WALL SHEAR STRESS	.18017E+03 DYNE/CM**2
COEFFICIENT OF FRICTION	.84878E-04	INITIAL PROPELLANT TEMP	294.15 KELVIN
AVERAGE ROUGHNESS HEIGHT	.001632 CM	CF/CFZERO EXPRESSION (IBLOW)	4

DZERO (MIC)	ROUGH (MIC)	XSTPD (MIC)	XSTPF (MIC)	XSTAP (MIC)	XSTFD (MIC)	XLAMAP ...	XLAMPF (CAL/CM-S-K)	XLAMFF ...	GAMAPF (CM2/S)	GAMAFF (CM2/S)
40.000	16.318	19.3804	.4729	1.3733	18.2401	.179E-03	.228E-03	.460E-03	.142E+00	.173E+00

DZERO (MIC)	R-EROS (CM/S)	R-NEROS (CM/S)	EBETA	BETAF	TS (K)	TSB (K)	TSPF ...	TSFF (PERCENT)	TSAP ...	TSBN (K)
40.000	1.7427	1.3055	.3349	.0465	1136.89	1136.89	12.64	45.62	41.74	-114.92

1 5 1.74268 1.74268 BOUNDARY LAYER THICKNESS = 2900.00 MICRONS
TAVBL = 2067.6 XMEW = .90942E-03 GRAMS/CM-SEC AMWBL = 26.4695

***** EROSIVE BURNING OUTPUT *****

FREE STREAM VELOCITY	20000.0 CM/SEC	FREE STREAM GAS PRESSURE	68.027 ATMS
BOUND.LAYER TEMPERATURE	2067.6 KELVIN	BOUND.LAYER GAS DENSITY	.10613E-01 GRAMS/CM**3
MOLECULAR VISCOSITY	.90942E-03 GRAMS/CM-S	PIPE HYDRAULIC DIAM.	2.00 CM
REYNOLDS NUMBER	.46682E+06	BLOWING PARAMETER, B	.58104E+01
COEFFICIENT OF FRICTION (B=0)	.48579E-02	WALL SHEAR STRESS	.18006E+03 DYNE/CM**2
COEFFICIENT OF FRICTION	.84827E-04	INITIAL PROPELLANT TEMP	294.15 KELVIN
AVERAGE ROUGHNESS HEIGHT	.001632 CM	CF/CFZERO EXPRESSION (IBLOW)	4

DZERO (MIC)	ROUGH (MIC)	XSTPD (MIC)	XSTPF (MIC)	XSTAP (MIC)	XSTFD (MIC)	XLAMAP ...	XLAMPF (CAL/CM-S-K)	XLAMFF ...	GAMAPF (CM2/S)	GAMAFF (CM2/S)
40.000	16.318	19.3805	.4729	1.3733	18.2403	.179E-03	.228E-03	.460E-03	.142E+00	.173E+00

DZERO (MIC)	R-EROS (CM/S)	R-NEROS (CM/S)	EBETA	BETAF	TS (K)	TSB (K)	TSPF ...	TSFF (PERCENT)	TSAP ...	TSBN (K)
40.000	1.7427	1.3055	.3349	.0465	1136.89	1136.89	12.64	45.62	41.75	-114.92

SURFACE NORMAL COORDINATE (CM)

	1	2	3	4	5	6	7	8	9	10
0	0.	.1000E-05	.2000E-05	.3000E-05	.4000E-05	.5000E-05	.6000E-05	.7000E-05	.8000E-05	.9000E-05
1	.1000E-04	.1100E-04	.1200E-04	.1300E-04	.1400E-04	.1500E-04	.1600E-04	.1700E-04	.1800E-04	.1900E-04
2	.2000E-04	.2100E-04	.2200E-04	.2300E-04	.2400E-04	.2500E-04	.2600E-04	.2700E-04	.2800E-04	.2900E-04
3	.3000E-04	.3100E-04	.3200E-04	.3300E-04	.3400E-04	.3500E-04	.3600E-04	.3700E-04	.3800E-04	.3900E-04
4	.4000E-04	.4100E-04	.4200E-04	.4300E-04	.4400E-04	.4500E-04	.4600E-04	.4700E-04	.4800E-04	.4900E-04
5	.5000E-04	.5100E-04	.5200E-04	.5300E-04	.5400E-04	.5500E-04	.5600E-04	.5700E-04	.5800E-04	.5900E-04
6	.6000E-04	.6100E-04	.6200E-04	.6300E-04	.6400E-04	.6500E-04	.6600E-04	.6700E-04	.6800E-04	.6900E-04
7	.7000E-04	.7100E-04	.7200E-04	.7300E-04	.7400E-04	.7500E-04	.7600E-04	.7700E-04	.7800E-04	.7900E-04
8	.8000E-04	.8100E-04	.8200E-04	.8300E-04	.8400E-04	.8500E-04	.8600E-04	.8700E-04	.8800E-04	.8900E-04
9	.9000E-04	.9100E-04	.9200E-04	.9300E-04	.9400E-04	.9500E-04	.9600E-04	.9700E-04	.9800E-04	.9900E-04
10	.1000E-03	.1100E-03	.1200E-03	.1300E-03	.1400E-03	.1500E-03	.1600E-03	.1700E-03	.1800E-03	.1900E-03
11	.2000E-03	.2100E-03	.2200E-03	.2300E-03	.2400E-03	.2500E-03	.2600E-03	.2700E-03	.2800E-03	.2900E-03
12	.3000E-03	.3100E-03	.3200E-03	.3300E-03	.3400E-03	.3500E-03	.3600E-03	.3700E-03	.3800E-03	.3900E-03
13	.4000E-03	.4100E-03	.4200E-03	.4300E-03	.4400E-03	.4500E-03	.4600E-03	.4700E-03	.4800E-03	.4900E-03
14	.5000E-03	.5100E-03	.5200E-03	.5300E-03	.5400E-03	.5500E-03	.5600E-03	.5700E-03	.5800E-03	.5900E-03
15	.6000E-03	.6100E-03	.6200E-03	.6300E-03	.6400E-03	.6500E-03	.6600E-03	.6700E-03	.6800E-03	.6900E-03
16	.7000E-03	.7100E-03	.7200E-03	.7300E-03	.7400E-03	.7500E-03	.7600E-03	.7700E-03	.7800E-03	.7900E-03
17	.8000E-03	.8100E-03	.8200E-03	.8300E-03	.8400E-03	.8500E-03	.8600E-03	.8700E-03	.8800E-03	.8900E-03
18	.9000E-03	.9100E-03	.9200E-03	.9300E-03	.9400E-03	.9500E-03	.9600E-03	.9700E-03	.9800E-03	.9900E-03
19	.1000E-02	.1100E-02	.1200E-02	.1300E-02	.1400E-02	.1500E-02	.1600E-02	.1700E-02	.1800E-02	.1900E-02
20	.2000E-02	.2100E-02	.2200E-02	.2300E-02	.2400E-02	.2500E-02	.2600E-02	.2700E-02	.2800E-02	.2900E-02
21	.3000E-02	.3100E-02	.3200E-02	.3300E-02	.3400E-02	.3500E-02	.3600E-02	.3700E-02	.3800E-02	.3900E-02
22	.4000E-02	.4100E-02	.4200E-02	.4300E-02	.4400E-02	.4500E-02	.4600E-02	.4700E-02	.4800E-02	.4900E-02
23	.5000E-02	.5100E-02	.5200E-02	.5300E-02	.5400E-02	.5500E-02	.5600E-02	.5700E-02	.5800E-02	.5900E-02
24	.6000E-02	.6100E-02	.6200E-02	.6300E-02	.6400E-02	.6500E-02	.6600E-02	.6700E-02	.6800E-02	.6900E-02
25	.7000E-02	.7100E-02	.7200E-02	.7300E-02	.7400E-02	.7500E-02	.7600E-02	.7700E-02	.7800E-02	.7900E-02
26	.8000E-02	.8100E-02	.8200E-02	.8300E-02	.8400E-02	.8500E-02	.8600E-02	.8700E-02	.8800E-02	.8900E-02
27	.9000E-02	.9100E-02	.9200E-02	.9300E-02	.9400E-02	.9500E-02	.9600E-02	.9700E-02	.9800E-02	.9900E-02
28	.1000E-01	.1100E-01	.1200E-01	.1300E-01	.1400E-01	.1500E-01	.1600E-01	.1700E-01	.1800E-01	.1900E-01
29	.2000E-01	.2100E-01	.2200E-01	.2300E-01	.2400E-01	.2500E-01	.2600E-01	.2700E-01	.2800E-01	.2900E-01
30	.3000E-01	.3100E-01	.3200E-01	.3300E-01	.3400E-01	.3500E-01	.3600E-01	.3700E-01	.3800E-01	.3900E-01
31	.4000E-01	.4100E-01	.4200E-01	.4300E-01	.4400E-01	.4500E-01	.4600E-01	.4700E-01	.4800E-01	.4900E-01
32	.5000E-01	.5100E-01	.5200E-01	.5300E-01	.5400E-01	.5500E-01	.5600E-01	.5700E-01	.5800E-01	.5900E-01
33	.6000E-01	.6100E-01	.6200E-01	.6300E-01	.6400E-01	.6500E-01	.6600E-01	.6700E-01	.6800E-01	.6900E-01
34	.7000E-01	.7100E-01	.7200E-01	.7300E-01	.7400E-01	.7500E-01	.7600E-01	.7700E-01	.7800E-01	.7900E-01
35	.8000E-01	.8100E-01	.8200E-01	.8300E-01	.8400E-01	.8500E-01	.8600E-01	.8700E-01	.8800E-01	.8900E-01
36	.9000E-01	.9100E-01	.9200E-01	.9300E-01	.9400E-01	.9500E-01	.9600E-01	.9700E-01	.9800E-01	.9900E-01
37	.1000E+00	.1100E+00	.1200E+00	.1300E+00	.1400E+00	.1500E+00	.1600E+00	.1700E+00	.1800E+00	.1900E+00
38	.2000E+00	.2100E+00	.2200E+00	.2300E+00	.2400E+00	.2500E+00	.2600E+00	.2700E+00	.2800E+00	.2900E+00
39	.3000E+00	.3100E+00	.3200E+00	.3300E+00	.3400E+00	.3500E+00	.3600E+00	.3700E+00	.3800E+00	.3900E+00
40	.4000E+00	.4100E+00	.4200E+00	.4300E+00	.4400E+00	.4500E+00	.4600E+00	.4700E+00	.4800E+00	.4900E+00
41	.5000E+00	.5100E+00	.5200E+00	.5300E+00	.5400E+00	.5500E+00	.5600E+00	.5700E+00	.5800E+00	.5900E+00
42	.6000E+00	.6100E+00	.6200E+00	.6300E+00	.6400E+00	.6500E+00	.6600E+00	.6700E+00	.6800E+00	.6900E+00
43	.7000E+00	.7100E+00	.7200E+00	.7300E+00	.7400E+00	.7500E+00	.7600E+00	.7700E+00	.7800E+00	.7900E+00
44	.8000E+00	.8100E+00	.8200E+00	.8300E+00	.8400E+00	.8500E+00	.8600E+00	.8700E+00	.8800E+00	.8900E+00
45	.9000E+00	.9100E+00	.9200E+00	.9300E+00	.9400E+00	.9500E+00	.9600E+00	.9700E+00	.9800E+00	.9900E+00
46	.1000E+01									

CROSSFLOW VELOCITY (CM/SEC)

	1	2	3	4	5	6	7	8	9	10
0	0.	.1983E+00	.3973E+00	.5969E+00	.7972E+00	.9982E+00	.1200E+01	.1402E+01	.1605E+01	.1809E+01
1	.2013E+01	.2218E+01	.2423E+01	.2630E+01	.2837E+01	.3044E+01	.3253E+01	.3462E+01	.3672E+01	.3882E+01
2	.4093E+01	.4305E+01	.4517E+01	.4731E+01	.4944E+01	.5159E+01	.5374E+01	.5590E+01	.5807E+01	.6024E+01
3	.6243E+01	.6461E+01	.6681E+01	.6901E+01	.7122E+01	.7344E+01	.7566E+01	.7789E+01	.8013E+01	.8238E+01
4	.8463E+01	.8689E+01	.8916E+01	.9144E+01	.9372E+01	.9601E+01	.9831E+01	.1006E+02	.1029E+02	.1052E+02
5	.1076E+02	.1099E+02	.1123E+02	.1146E+02	.1170E+02	.1193E+02	.1217E+02	.1241E+02	.1265E+02	.1289E+02
6	.1313E+02	.1337E+02	.1361E+02	.1385E+02	.1410E+02	.1434E+02	.1459E+02	.1483E+02	.1508E+02	.1533E+02
7	.1558E+02	.1582E+02	.1607E+02	.1633E+02	.1658E+02	.1683E+02	.1708E+02	.1734E+02	.1759E+02	.1785E+02
8	.1810E+02	.1836E+02	.1862E+02	.1888E+02	.1914E+02	.1940E+02	.1966E+02	.1992E+02	.2018E+02	.2045E+02
9	.2071E+02	.2098E+02	.2125E+02	.2151E+02	.2178E+02	.2205E+02	.2232E+02	.2259E+02	.2286E+02	.2313E+02
10	.2341E+02	.2619E+02	.2906E+02	.3202E+02	.3507E+02	.3822E+02	.4146E+02	.4481E+02	.4825E+02	.5180E+02
11	.5545E+02	.5921E+02	.6307E+02	.6704E+02	.7113E+02	.7532E+02	.7963E+02	.8405E+02	.8858E+02	.9323E+02
12	.9799E+02	.1029E+03	.1079E+03	.1130E+03	.1182E+03	.1235E+03	.1289E+03	.1345E+03	.1402E+03	.1459E+03
13	.1518E+03	.1578E+03	.1639E+03	.1701E+03	.1763E+03	.1827E+03	.1892E+03	.1958E+03	.2025E+03	.2092E+03
14	.2161E+03	.2230E+03	.2300E+03	.2371E+03	.2442E+03	.2515E+03	.2588E+03	.2662E+03	.2736E+03	.2811E+03
15	.2887E+03	.2963E+03	.3040E+03	.3118E+03	.3196E+03	.3274E+03	.3353E+03	.3433E+03	.3512E+03	.3593E+03
16	.3673E+03	.3755E+03	.3836E+03	.3918E+03	.4000E+03	.4082E+03	.4165E+03	.4248E+03	.4332E+03	.4415E+03
17	.4499E+03	.4583E+03	.4667E+03	.4751E+03	.4836E+03	.4921E+03	.5006E+03	.5091E+03	.5176E+03	.5261E+03
18	.5347E+03	.5432E+03	.5518E+03	.5603E+03	.5689E+03	.5775E+03	.5861E+03	.5947E+03	.6033E+03	.6119E+03
19	.6205E+03	.7065E+03	.7921E+03	.8769E+03	.9606E+03	.1043E+04	.1124E+04	.1204E+04	.1282E+04	.1359E+04
20	.1435E+04	.1509E+04	.1582E+04	.1653E+04	.1723E+04	.1792E+04	.1859E+04	.1926E+04	.1991E+04	.2055E+04
21	.2118E+04	.2180E+04	.2241E+04	.2301E+04	.2360E+04	.2418E+04	.2475E+04	.2531E+04	.2586E+04	.2641E+04
22	.2695E+04	.2748E+04	.2800E+04	.2852E+04	.2903E+04	.2953E+04	.3003E+04	.3052E+04	.3100E+04	.3148E+04
23	.3195E+04	.3242E+04	.3288E+04	.3333E+04	.3378E+04	.3423E+04	.3466E+04	.3510E+04	.3553E+04	.3595E+04
24	.3637E+04	.3679E+04	.3720E+04	.3761E+04	.3801E+04	.3841E+04	.3881E+04	.3920E+04	.3959E+04	.3997E+04
25	.4035E+04	.4073E+04	.4110E+04	.4147E+04	.4184E+04	.4220E+04	.4256E+04	.4292E+04	.4327E+04	.4362E+04
26	.4397E+04	.4432E+04	.4466E+04	.4500E+04	.4533E+04	.4567E+04	.4600E+04	.4633E+04	.4665E+04	.4698E+04
27	.4730E+04	.4762E+04	.4793E+04	.4825E+04	.4856E+04	.4887E+04	.4917E+04	.4948E+04	.4978E+04	.5008E+04
28	.5038E+04	.5325E+04	.5595E+04	.5849E+04	.6089E+04	.6317E+04	.6534E+04	.6741E+04	.6940E+04	.7131E+04
29	.7314E+04	.7490E+04	.7660E+04	.7825E+04	.7984E+04	.8138E+04	.8287E+04	.8432E+04	.8573E+04	.8710E+04
30	.8844E+04	.8974E+04	.9101E+04	.9225E+04	.9346E+04	.9464E+04	.9580E+04	.9693E+04	.9803E+04	.9912E+04
31	.1002E+05	.1012E+05	.1022E+05	.1033E+05	.1042E+05	.1052E+05	.1062E+05	.1071E+05	.1080E+05	.1089E+05
32	.1098E+05	.1107E+05	.1115E+05	.1124E+05	.1132E+05	.1140E+05	.1148E+05	.1156E+05	.1164E+05	.1172E+05
33	.1180E+05	.1187E+05	.1195E+05	.1202E+05	.1209E+05	.1217E+05	.1224E+05	.1231E+05	.1238E+05	.1245E+05
34	.1251E+05	.1258E+05	.1265E+05	.1271E+05	.1278E+05	.1284E+05	.1290E+05	.1297E+05	.1303E+05	.1309E+05
35	.1315E+05	.1321E+05	.1327E+05	.1333E+05	.1339E+05	.1344E+05	.1350E+05	.1356E+05	.1361E+05	.1367E+05
36	.1372E+05	.1378E+05	.1383E+05	.1389E+05	.1394E+05	.1399E+05	.1404E+05	.1410E+05	.1415E+05	.1420E+05
37	.1425E+05	.1473E+05	.1518E+05	.1560E+05	.1599E+05	.1636E+05	.1671E+05	.1704E+05	.1735E+05	.1765E+05
38	.1794E+05	.1822E+05	.1848E+05	.1874E+05	.1898E+05	.1922E+05	.1945E+05	.1967E+05	.1989E+05	.2009E+05

AVERAGE RESISTANCE COEFFICIENT

	1	2	3	4	5	6	7	8	9	10
0	.1000E+01	.1000E+01	.1000E+01	.1000E+01	.1000E+01	.1000E+01	.1000E+01	.1000E+01	.1000E+01	.1000E+01
1	.1000E+01	.1000E+01	.1000E+01	.1000E+01	.1000E+01	.1000E+01	.1000E+01	.1000E+01	.1000E+01	.1000E+01
2	.9999E+00	.9999E+00	.9999E+00	.9999E+00	.9999E+00	.9999E+00	.9999E+00	.9999E+00	.9999E+00	.9999E+00
3	.9999E+00	.9999E+00	.9999E+00	.9999E+00	.9998E+00	.9998E+00	.9998E+00	.9998E+00	.9998E+00	.9998E+00
4	.9998E+00	.9998E+00	.9998E+00	.9997E+00	.9997E+00	.9997E+00	.9997E+00	.9997E+00	.9997E+00	.9997E+00
5	.9997E+00	.9996E+00	.9996E+00	.9996E+00	.9996E+00	.9996E+00	.9996E+00	.9995E+00	.9995E+00	.9995E+00
6	.9995E+00	.9995E+00	.9995E+00	.9994E+00	.9994E+00	.9994E+00	.9994E+00	.9994E+00	.9993E+00	.9993E+00
7	.9993E+00	.9993E+00	.9992E+00	.9992E+00	.9992E+00	.9992E+00	.9991E+00	.9991E+00	.9991E+00	.9991E+00

8	.9990E+00	.9990E+00	.9990E+00	.9990E+00	.9989E+00	.9989E+00	.9989E+00	.9989E+00	.9988E+00	.9988E+00
9	.9988E+00	.9987E+00	.9987E+00	.9987E+00	.9986E+00	.9986E+00	.9986E+00	.9985E+00	.9985E+00	.9985E+00
10	.9984E+00	.9981E+00	.9977E+00	.9972E+00	.9967E+00	.9961E+00	.9955E+00	.9948E+00	.9940E+00	.9932E+00
11	.9923E+00	.9914E+00	.9903E+00	.9892E+00	.9880E+00	.9868E+00	.9854E+00	.9840E+00	.9824E+00	.9808E+00
12	.9791E+00	.9773E+00	.9755E+00	.9735E+00	.9714E+00	.9693E+00	.9670E+00	.9647E+00	.9623E+00	.9598E+00
13	.9572E+00	.9545E+00	.9517E+00	.9489E+00	.9460E+00	.9430E+00	.9399E+00	.9368E+00	.9336E+00	.9303E+00
14	.9270E+00	.9236E+00	.9202E+00	.9167E+00	.9131E+00	.9095E+00	.9059E+00	.9022E+00	.8985E+00	.8948E+00
15	.8910E+00	.8872E+00	.8834E+00	.8795E+00	.8756E+00	.8717E+00	.8678E+00	.8639E+00	.8600E+00	.8561E+00
16	.8521E+00	.8482E+00	.8442E+00	.8403E+00	.8363E+00	.8324E+00	.8284E+00	.8245E+00	.8205E+00	.8166E+00
17	.8127E+00	.8088E+00	.8049E+00	.8010E+00	.7972E+00	.7933E+00	.7895E+00	.7857E+00	.7819E+00	.7781E+00
18	.7743E+00	.7706E+00	.7669E+00	.7632E+00	.7595E+00	.7558E+00	.7522E+00	.7485E+00	.7449E+00	.7414E+00
19	.7378E+00	.7036E+00	.6717E+00	.6420E+00	.6145E+00	.5891E+00	.5656E+00	.5438E+00	.5236E+00	.5048E+00
20	.4873E+00	.4710E+00	.4557E+00	.4414E+00	.4280E+00	.4154E+00	.4036E+00	.3924E+00	.3818E+00	.3718E+00
21	.3623E+00	.3533E+00	.3448E+00	.3367E+00	.3290E+00	.3216E+00	.3145E+00	.3078E+00	.3014E+00	.2952E+00
22	.2893E+00	.2837E+00	.2782E+00	.2730E+00	.2680E+00	.2631E+00	.2585E+00	.2540E+00	.2497E+00	.2455E+00
23	.2415E+00	.2376E+00	.2338E+00	.2301E+00	.2266E+00	.2232E+00	.2199E+00	.2167E+00	.2136E+00	.2105E+00
24	.2076E+00	.2047E+00	.2020E+00	.1993E+00	.1967E+00	.1941E+00	.1916E+00	.1892E+00	.1869E+00	.1846E+00
25	.1823E+00	.1801E+00	.1780E+00	.1759E+00	.1739E+00	.1719E+00	.1700E+00	.1681E+00	.1663E+00	.1645E+00
26	.1627E+00	.1610E+00	.1593E+00	.1577E+00	.1561E+00	.1545E+00	.1529E+00	.1514E+00	.1499E+00	.1485E+00
27	.1470E+00	.1457E+00	.1443E+00	.1429E+00	.1416E+00	.1403E+00	.1391E+00	.1378E+00	.1366E+00	.1354E+00
28	.1342E+00	.1235E+00	.1143E+00	.1065E+00	.9973E-01	.9378E-01	.8853E-01	.8385E-01	.7966E-01	.7588E-01
29	.7245E-01	.6933E-01	.6647E-01	.6385E-01	.6144E-01	.5920E-01	.5713E-01	.5520E-01	.5340E-01	.5172E-01
30	.5015E-01	.4867E-01	.4728E-01	.4596E-01	.4473E-01	.4355E-01	.4244E-01	.4139E-01	.4039E-01	.3944E-01
31	.3853E-01	.3766E-01	.3684E-01	.3605E-01	.3529E-01	.3457E-01	.3388E-01	.3321E-01	.3257E-01	.3196E-01
32	.3137E-01	.3080E-01	.3025E-01	.2972E-01	.2921E-01	.2872E-01	.2825E-01	.2779E-01	.2734E-01	.2691E-01
33	.2650E-01	.2609E-01	.2570E-01	.2532E-01	.2496E-01	.2460E-01	.2425E-01	.2392E-01	.2359E-01	.2327E-01
34	.2296E-01	.2266E-01	.2237E-01	.2208E-01	.2180E-01	.2153E-01	.2127E-01	.2101E-01	.2076E-01	.2052E-01
35	.2028E-01	.2004E-01	.1981E-01	.1959E-01	.1937E-01	.1916E-01	.1895E-01	.1875E-01	.1855E-01	.1836E-01
36	.1817E-01	.1798E-01	.1780E-01	.1762E-01	.1744E-01	.1727E-01	.1710E-01	.1694E-01	.1678E-01	.1662E-01
37	.1646E-01	.1505E-01	.1387E-01	.1286E-01	.1199E-01	.1124E-01	.1057E-01	.9983E-02	.9457E-02	.8986E-02
38	.8560E-02	.8173E-02	.7821E-02	.7498E-02	.7202E-02	.6928E-02	.6675E-02	.6440E-02	.6222E-02	.6018E-02

*** HAMANN VELOCITY COUPLED REPONSE CALCULATIONS ***

JJ	DZERO (MICRONS)	RATE (CM/S)	GRAD	C(JJ,1)	C(JJ,2)	C(JJ,3)	C(JJ,4)	PXN
1	40.000	1.7427	660.5863	0.	.7131E+01	.7906E+01	.8902E+01	.40042

NDF	OMEGA (CPS)	RE(RSP/N)	IM(RSP/N)	RE(RSP)	IM(RSP)	MAG(RSP)	PHASE (DEGREES)	MAG(RSP/N)
.181E-01	.100E+02	.100E+01	.699E-02	.401E+00	.280E-02	.401E+00	.401E+00	.100E+01
.203E-01	.112E+02	.100E+01	.784E-02	.401E+00	.314E-02	.401E+00	.449E+00	.100E+01
.227E-01	.126E+02	.100E+01	.880E-02	.401E+00	.352E-02	.401E+00	.504E+00	.100E+01
.255E-01	.141E+02	.100E+01	.986E-02	.401E+00	.395E-02	.401E+00	.565E+00	.100E+01
.286E-01	.158E+02	.100E+01	.111E-01	.401E+00	.443E-02	.401E+00	.633E+00	.100E+01
.321E-01	.178E+02	.100E+01	.124E-01	.401E+00	.497E-02	.401E+00	.710E+00	.100E+01
.360E-01	.200E+02	.100E+01	.139E-01	.401E+00	.557E-02	.401E+00	.796E+00	.100E+01
.404E-01	.224E+02	.100E+01	.156E-01	.401E+00	.624E-02	.401E+00	.891E+00	.100E+01
.453E-01	.251E+02	.100E+01	.174E-01	.401E+00	.699E-02	.401E+00	.998E+00	.100E+01
.509E-01	.282E+02	.100E+01	.195E-01	.401E+00	.782E-02	.401E+00	.112E+01	.100E+01
.571E-01	.316E+02	.100E+01	.219E-01	.401E+00	.875E-02	.401E+00	.125E+01	.100E+01
.641E-01	.355E+02	.100E+01	.245E-01	.402E+00	.979E-02	.402E+00	.140E+01	.100E+01
.719E-01	.398E+02	.100E+01	.273E-01	.402E+00	.109E-01	.402E+00	.156E+01	.100E+01
.806E-01	.447E+02	.100E+01	.305E-01	.402E+00	.122E-01	.402E+00	.174E+01	.100E+01
.905E-01	.501E+02	.101E+01	.340E-01	.403E+00	.136E-01	.403E+00	.194E+01	.101E+01
.102E+00	.562E+02	.101E+01	.379E-01	.403E+00	.152E-01	.403E+00	.216E+01	.101E+01
.114E+00	.631E+02	.101E+01	.421E-01	.404E+00	.169E-01	.404E+00	.239E+01	.101E+01
.128E+00	.708E+02	.101E+01	.467E-01	.405E+00	.187E-01	.405E+00	.265E+01	.101E+01
.143E+00	.794E+02	.101E+01	.517E-01	.405E+00	.207E-01	.406E+00	.292E+01	.101E+01
.161E+00	.891E+02	.102E+01	.570E-01	.407E+00	.228E-01	.407E+00	.322E+01	.102E+01
.181E+00	.100E+03	.102E+01	.627E-01	.408E+00	.251E-01	.409E+00	.352E+01	.102E+01
.203E+00	.112E+03	.102E+01	.687E-01	.410E+00	.275E-01	.411E+00	.384E+01	.103E+01
.227E+00	.126E+03	.103E+01	.749E-01	.412E+00	.300E-01	.413E+00	.417E+01	.103E+01
.255E+00	.141E+03	.103E+01	.814E-01	.414E+00	.326E-01	.415E+00	.450E+01	.104E+01
.286E+00	.158E+03	.104E+01	.878E-01	.416E+00	.352E-01	.418E+00	.483E+01	.104E+01
.321E+00	.178E+03	.105E+01	.943E-01	.419E+00	.378E-01	.421E+00	.515E+01	.105E+01
.360E+00	.200E+03	.106E+01	.101E+00	.422E+00	.403E-01	.424E+00	.545E+01	.106E+01
.404E+00	.224E+03	.106E+01	.107E+00	.426E+00	.428E-01	.428E+00	.573E+01	.107E+01
.453E+00	.251E+03	.107E+01	.113E+00	.430E+00	.451E-01	.432E+00	.598E+01	.108E+01
.509E+00	.282E+03	.108E+01	.118E+00	.434E+00	.472E-01	.437E+00	.620E+01	.109E+01
.571E+00	.316E+03	.110E+01	.123E+00	.439E+00	.491E-01	.442E+00	.638E+01	.110E+01
.641E+00	.355E+03	.111E+01	.127E+00	.444E+00	.507E-01	.447E+00	.652E+01	.112E+01
.719E+00	.398E+03	.112E+01	.130E+00	.449E+00	.520E-01	.452E+00	.661E+01	.113E+01
.806E+00	.447E+03	.113E+01	.132E+00	.454E+00	.529E-01	.457E+00	.665E+01	.114E+01
.905E+00	.501E+03	.115E+01	.134E+00	.460E+00	.535E-01	.463E+00	.664E+01	.116E+01

.102E+01	.562E+03	.116E+01	.134E+00	.465E+00	.537E-01	.469E+00	.658E+01	.117E+01
.114E+01	.631E+03	.118E+01	.133E+00	.471E+00	.534E-01	.474E+00	.647E+01	.118E+01
.128E+01	.708E+03	.119E+01	.132E+00	.477E+00	.527E-01	.480E+00	.630E+01	.120E+01
.143E+01	.794E+03	.121E+01	.129E+00	.483E+00	.515E-01	.485E+00	.609E+01	.121E+01
.161E+01	.891E+03	.122E+01	.124E+00	.488E+00	.498E-01	.491E+00	.583E+01	.123E+01
.181E+01	.100E+04	.123E+01	.119E+00	.494E+00	.477E-01	.496E+00	.552E+01	.124E+01
.203E+01	.112E+04	.125E+01	.113E+00	.499E+00	.451E-01	.501E+00	.516E+01	.125E+01
.227E+01	.126E+04	.126E+01	.105E+00	.504E+00	.420E-01	.506E+00	.476E+01	.126E+01
.255E+01	.141E+04	.127E+01	.960E-01	.509E+00	.385E-01	.511E+00	.432E+01	.128E+01
.286E+01	.158E+04	.128E+01	.860E-01	.514E+00	.344E-01	.515E+00	.383E+01	.129E+01
.321E+01	.178E+04	.129E+01	.749E-01	.518E+00	.300E-01	.519E+00	.331E+01	.130E+01
.360E+01	.200E+04	.130E+01	.627E-01	.522E+00	.251E-01	.522E+00	.275E+01	.130E+01
.404E+01	.224E+04	.131E+01	.495E-01	.525E+00	.196E-01	.525E+00	.216E+01	.131E+01
.453E+01	.251E+04	.132E+01	.353E-01	.528E+00	.141E-01	.528E+00	.154E+01	.132E+01
.509E+01	.282E+04	.132E+01	.203E-01	.530E+00	.814E-02	.530E+00	.881E+00	.132E+01
.571E+01	.316E+04	.133E+01	.457E-02	.531E+00	.183E-02	.531E+00	.197E+00	.133E+01
.641E+01	.355E+04	.133E+01	-.119E-01	.532E+00	-.476E-02	.532E+00	-.512E+00	.133E+01
.719E+01	.398E+04	.133E+01	-.289E-01	.533E+00	-.116E-01	.533E+00	-.125E+01	.133E+01
.806E+01	.447E+04	.133E+01	-.465E-01	.532E+00	-.186E-01	.533E+00	-.200E+01	.133E+01
.905E+01	.501E+04	.133E+01	-.644E-01	.531E+00	-.258E-01	.532E+00	-.278E+01	.133E+01
.102E+02	.562E+04	.132E+01	-.826E-01	.529E+00	-.331E-01	.530E+00	-.358E+01	.132E+01
.114E+02	.631E+04	.132E+01	-.101E+00	.527E+00	-.405E-01	.528E+00	-.439E+01	.132E+01
.128E+02	.708E+04	.131E+01	-.119E+00	.524E+00	-.478E-01	.526E+00	-.522E+01	.131E+01
.143E+02	.794E+04	.130E+01	-.138E+00	.520E+00	-.552E-01	.523E+00	-.606E+01	.131E+01
.161E+02	.891E+04	.129E+01	-.156E+00	.515E+00	-.625E-01	.519E+00	-.692E+01	.130E+01
.181E+02	.100E+05	.127E+01	-.174E+00	.510E+00	-.697E-01	.514E+00	-.779E+01	.128E+01
.203E+02	.112E+05	.126E+01	-.192E+00	.504E+00	-.767E-01	.509E+00	-.866E+01	.127E+01
.227E+02	.126E+05	.124E+01	-.209E+00	.497E+00	-.836E-01	.504E+00	-.955E+01	.126E+01
.255E+02	.141E+05	.122E+01	-.225E+00	.489E+00	-.902E-01	.498E+00	-.104E+02	.124E+01
.286E+02	.158E+05	.120E+01	-.241E+00	.481E+00	-.965E-01	.491E+00	-.113E+02	.123E+01
.321E+02	.178E+05	.118E+01	-.256E+00	.473E+00	-.102E+00	.484E+00	-.122E+02	.121E+01
.360E+02	.200E+05	.116E+01	-.270E+00	.464E+00	-.108E+00	.476E+00	-.131E+02	.119E+01
.404E+02	.224E+05	.113E+01	-.283E+00	.454E+00	-.113E+00	.468E+00	-.140E+02	.117E+01
.453E+02	.251E+05	.111E+01	-.296E+00	.444E+00	-.118E+00	.459E+00	-.149E+02	.115E+01
.509E+02	.282E+05	.108E+01	-.307E+00	.433E+00	-.123E+00	.450E+00	-.158E+02	.112E+01
.571E+02	.316E+05	.105E+01	-.317E+00	.422E+00	-.127E+00	.441E+00	-.167E+02	.110E+01
.641E+02	.355E+05	.103E+01	-.326E+00	.411E+00	-.130E+00	.431E+00	-.176E+02	.108E+01
.719E+02	.398E+05	.997E+00	-.334E+00	.399E+00	-.134E+00	.421E+00	-.185E+02	.105E+01
.806E+02	.447E+05	.967E+00	-.340E+00	.387E+00	-.136E+00	.411E+00	-.194E+02	.103E+01
.905E+02	.501E+05	.937E+00	-.346E+00	.375E+00	-.138E+00	.400E+00	-.203E+02	.999E+00
.102E+03	.562E+05	.907E+00	-.350E+00	.363E+00	-.140E+00	.389E+00	-.211E+02	.972E+00
.114E+03	.631E+05	.876E+00	-.353E+00	.351E+00	-.141E+00	.378E+00	-.220E+02	.945E+00
.128E+03	.708E+05	.846E+00	-.355E+00	.339E+00	-.142E+00	.367E+00	-.228E+02	.917E+00
.143E+03	.794E+05	.815E+00	-.356E+00	.326E+00	-.143E+00	.356E+00	-.236E+02	.890E+00
.161E+03	.891E+05	.785E+00	-.356E+00	.314E+00	-.143E+00	.345E+00	-.244E+02	.862E+00
.181E+03	.100E+06	.754E+00	-.355E+00	.302E+00	-.142E+00	.334E+00	-.252E+02	.834E+00

J. SAMPLE CASE 8

This case is a velocity coupled response calculation using the Zeldovich/Novozhilov method. As before, the propellant oxidizer distribution is unimodal with a mean diameter of 40 microns and a mode width parameter equal to one. The oxidizer mass fraction is equal to .88 and all other default values are assumed. The crossflow velocity is taken to be 20000 centimeters per second. In the output corresponding to this case, the erosive burning calculation is the same as that presented in the previous example. However, additional output representing the perturbation of the crossflow velocity and the initial solid propellant temperature within the erosive burning framework is also presented.

```
$FLAG $
$PARMST $
$PROPDT $
$ALUMDT $
$EROSDT UINF=20000. $
$RESPDT IRVZN=1 $
$OXDIST DBARI(1)=40., SIGMAI(1)=1.0, ALFAI(1)=.88, MODES=1 $
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Figure 10. Data Deck for Sample Case Number 8.

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THE CONVERGENCE ON THE EROSIVE BURNING RATE FOLLOWS

        2    1  1.73913      1.74268      BOUNDARY LAYER THICKNESS = 2900.00 MICRONS
                                          TAVBL = 2067.6    XMEW =    .90942E-03 GRAMS/CM-SEC    AMWBL =     26.4695

        2    2  1.73972      1.73913      BOUNDARY LAYER THICKNESS = 2900.00 MICRONS
                                          TAVBL = 2067.5    XMEW =    .90940E-03 GRAMS/CM-SEC    AMWBL =     26.4695

        2    3  1.73964      1.73964      BOUNDARY LAYER THICKNESS = 2900.00 MICRONS
                                          TAVBL = 2067.5    XMEW =    .90940E-03 GRAMS/CM-SEC    AMWBL =     26.4695

                                   *****  EROSIVE BURNING OUTPUT  *****

  FREE STREAM VELOCITY                19900.0 CM/SEC        FREE STREAM GAS PRESSURE      68.027 ATMS
  FREE STREAM TEMPERATURE              2067.5 KELVIN        FREE STREAM GAS DENSITY     .10614E-01 GRAMS/CM**3
  MOLECULAR VISCOSITY              .90940E-03 GRAMS/CM-S    PIPE HYDRAULIC DIAM.              2.00 CM
  REYNOLDS NUMBER                  .46452E+06               BLOWING PARAMETER, B        .58281E+01
  COEFFICIENT OF FRICTION (B=0)    .48587E-02               WALL SHEAR STRESS           .17570E+03 DYNE/CM**2
  COEFFICIENT OF FRICTION          .83601E-04               INITIAL PROPELLANT TEMP         294.15 KELVIN
  AVERAGE ROUGHNESS HEIGHT            .001632 CM            CF/CFZERO EXPRESSION (IBLOW)         4
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THE CONVERGENCE ON THE EROSIVE BURNING RATE FOLLOWS

        3    1  1.74569      1.74572      BOUNDARY LAYER THICKNESS = 2900.00 MICRONS
                                          TAVBL = 2067.7    XMEW =    .90944E-03 GRAMS/CM-SEC    AMWBL =     26.4695

                                   *****  EROSIVE BURNING OUTPUT  *****

  FREE STREAM VELOCITY                20100.0 CM/SEC        FREE STREAM GAS PRESSURE      68.027 ATMS
  FREE STREAM TEMPERATURE              2067.7 KELVIN        FREE STREAM GAS DENSITY     .10613E-01 GRAMS/CM**3
  MOLECULAR VISCOSITY              .90944E-03 GRAMS/CM-S    PIPE HYDRAULIC DIAM.              2.00 CM
  REYNOLDS NUMBER                  .46912E+06               BLOWING PARAMETER, B        .57930E+01
  COEFFICIENT OF FRICTION (B=0)    .48569E-02               WALL SHEAR STRESS           .18446E+03 DYNE/CM**2
  COEFFICIENT OF FRICTION          .86041E-04               INITIAL PROPELLANT TEMP         294.15 KELVIN
  AVERAGE ROUGHNESS HEIGHT            .001632 CM            CF/CFZERO EXPRESSION (IBLOW)         4
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THE CONVERGENCE ON THE EROSIVE BURNING RATE FOLLOWS

4	1	1.74236	1.73964	BOUNDARY LAYER THICKNESS = 2900.00 MICRONS TAVBL = 2067.5 XMEW = .90940E-03 GRAMS/CM-SEC	AMWBL = 26.4695
4	2	1.74190	1.74236	BOUNDARY LAYER THICKNESS = 2900.00 MICRONS TAVBL = 2067.6 XMEW = .90942E-03 GRAMS/CM-SEC	AMWBL = 26.4695
4	3	1.74197	1.74197	BOUNDARY LAYER THICKNESS = 2900.00 MICRONS TAVBL = 2067.6 XMEW = .90941E-03 GRAMS/CM-SEC	AMWBL = 26.4695

***** EROSIVE BURNING OUTPUT *****

FREE STREAM VELOCITY	20000.0 CM/SEC	FREE STREAM GAS PRESSURE	68.027 ATMS
FREE STREAM TEMPERATURE	2067.6 KELVIN	FREE STREAM GAS DENSITY	.10614E-01 GRAMS/CM**3
MOLECULAR VISCOSITY	.90941E-03 GRAMS/CM-S	PIPE HYDRAULIC DIAM.	2.00 CM
REYNOLDS NUMBER	.46683E+06	BLOWING PARAMETER, B	.58078E+01
COEFFICIENT OF FRICTION (B=0)	.48580E-02	WALL SHEAR STRESS	.18046E+03 DYNE/CM**2
COEFFICIENT OF FRICTION	.85016E-04	INITIAL PROPELLANT TEMP	292.68 KELVIN
AVERAGE ROUGHNESS HEIGHT	.001632 CM	CF/CFZERO EXPRESSION (IBLOW)	4

THE CONVERGENCE ON THE EROSIVE BURNING RATE FOLLOWS

5	1	1.74341	1.74339	BOUNDARY LAYER THICKNESS = 2900.00 MICRONS TAVBL = 2067.6 XMEW = .90942E-03 GRAMS/CM-SEC	AMWBL = 26.4695

***** EROSIVE BURNING OUTPUT *****

FREE STREAM VELOCITY	20000.0 CM/SEC	FREE STREAM GAS PRESSURE	68.027 ATMS
FREE STREAM TEMPERATURE	2067.6 KELVIN	FREE STREAM GAS DENSITY	.10613E-01 GRAMS/CM**3
MOLECULAR VISCOSITY	.90942E-03 GRAMS/CM-S	PIPE HYDRAULIC DIAM.	2.00 CM
REYNOLDS NUMBER	.46681E+06	BLOWING PARAMETER, B	.58129E+01
COEFFICIENT OF FRICTION (B=0)	.48578E-02	WALL SHEAR STRESS	.17969E+03 DYNE/CM**2
COEFFICIENT OF FRICTION	.84653E-04	INITIAL PROPELLANT TEMP	295.62 KELVIN
AVERAGE ROUGHNESS HEIGHT	.001632 CM	CF/CFZERO EXPRESSION (IBLOW)	4

*** ZELDOVICH/NOVOZHILOV VELOCITY COUPLED RESPONSE CALCULATIONS ***

	DZERO (MICRONS)	PXK	PXR	PXN	PXM	PXD	PXS	ES1	ES2
1	40.000	.2364E+00	.2991E-01	.3474E+00	.4394E-01	.2604E-07	.2806E-01	24091.13	24091.07

NDF	OMEGA (CPS)	RE(RSP/N)	IM(RSP/N)	RE(RSP)	IM(RSP)	MAG(RSP)	PHASE (DEGREES)	MAG(RSP/N)
.181E-01	.100E+02	.100E+01	.372E-02	.347E+00	.129E-02	.347E+00	.213E+00	.100E+01
.203E-01	.112E+02	.100E+01	.418E-02	.347E+00	.145E-02	.347E+00	.239E+00	.100E+01
.227E-01	.126E+02	.100E+01	.468E-02	.347E+00	.163E-02	.347E+00	.268E+00	.100E+01
.255E-01	.141E+02	.100E+01	.525E-02	.347E+00	.182E-02	.347E+00	.301E+00	.100E+01
.286E-01	.158E+02	.100E+01	.589E-02	.347E+00	.205E-02	.347E+00	.337E+00	.100E+01
.321E-01	.178E+02	.100E+01	.660E-02	.348E+00	.229E-02	.348E+00	.378E+00	.100E+01
.360E-01	.200E+02	.100E+01	.740E-02	.348E+00	.257E-02	.348E+00	.424E+00	.100E+01
.404E-01	.224E+02	.100E+01	.829E-02	.348E+00	.288E-02	.348E+00	.474E+00	.100E+01
.453E-01	.251E+02	.100E+01	.928E-02	.348E+00	.322E-02	.348E+00	.531E+00	.100E+01
.509E-01	.282E+02	.100E+01	.104E-01	.348E+00	.361E-02	.348E+00	.594E+00	.100E+01
.571E-01	.316E+02	.100E+01	.116E-01	.348E+00	.404E-02	.348E+00	.665E+00	.100E+01
.641E-01	.355E+02	.100E+01	.130E-01	.348E+00	.451E-02	.348E+00	.743E+00	.100E+01
.719E-01	.398E+02	.100E+01	.145E-01	.348E+00	.504E-02	.348E+00	.829E+00	.100E+01
.806E-01	.447E+02	.100E+01	.162E-01	.348E+00	.562E-02	.348E+00	.925E+00	.100E+01
.905E-01	.501E+02	.100E+01	.180E-01	.348E+00	.626E-02	.349E+00	.103E+01	.100E+01
.102E+00	.562E+02	.100E+01	.200E-01	.349E+00	.696E-02	.349E+00	.114E+01	.100E+01
.114E+00	.631E+02	.100E+01	.223E-01	.349E+00	.773E-02	.349E+00	.127E+01	.101E+01
.128E+00	.708E+02	.101E+01	.246E-01	.349E+00	.856E-02	.350E+00	.140E+01	.101E+01
.143E+00	.794E+02	.101E+01	.272E-01	.350E+00	.945E-02	.350E+00	.155E+01	.101E+01
.161E+00	.891E+02	.101E+01	.299E-01	.350E+00	.104E-01	.351E+00	.170E+01	.101E+01
.181E+00	.100E+03	.101E+01	.328E-01	.351E+00	.114E-01	.351E+00	.186E+01	.101E+01
.203E+00	.112E+03	.101E+01	.358E-01	.352E+00	.124E-01	.352E+00	.202E+01	.101E+01
.227E+00	.126E+03	.102E+01	.389E-01	.353E+00	.135E-01	.353E+00	.219E+01	.102E+01
.255E+00	.141E+03	.102E+01	.419E-01	.354E+00	.146E-01	.354E+00	.236E+01	.102E+01
.286E+00	.158E+03	.102E+01	.450E-01	.355E+00	.156E-01	.356E+00	.252E+01	.102E+01
.321E+00	.178E+03	.103E+01	.480E-01	.357E+00	.167E-01	.357E+00	.268E+01	.103E+01
.360E+00	.200E+03	.103E+01	.509E-01	.358E+00	.177E-01	.359E+00	.282E+01	.103E+01
.404E+00	.224E+03	.104E+01	.535E-01	.360E+00	.186E-01	.360E+00	.296E+01	.104E+01
.453E+00	.251E+03	.104E+01	.559E-01	.362E+00	.194E-01	.362E+00	.307E+01	.104E+01
.509E+00	.282E+03	.105E+01	.579E-01	.364E+00	.201E-01	.364E+00	.317E+01	.105E+01
.571E+00	.316E+03	.105E+01	.596E-01	.366E+00	.207E-01	.366E+00	.324E+01	.105E+01
.641E+00	.355E+03	.106E+01	.609E-01	.368E+00	.212E-01	.368E+00	.329E+01	.106E+01
.719E+00	.398E+03	.106E+01	.617E-01	.370E+00	.214E-01	.370E+00	.332E+01	.107E+01
.806E+00	.447E+03	.107E+01	.621E-01	.372E+00	.216E-01	.373E+00	.332E+01	.107E+01
.905E+00	.501E+03	.108E+01	.620E-01	.374E+00	.215E-01	.375E+00	.329E+01	.108E+01

.102E+01	.562E+03	.108E+01	.615E-01	.377E+00	.213E-01	.377E+00	.324E+01	.109E+01
.114E+01	.631E+03	.109E+01	.604E-01	.379E+00	.210E-01	.379E+00	.317E+01	.109E+01
.128E+01	.708E+03	.110E+01	.589E-01	.381E+00	.204E-01	.382E+00	.307E+01	.110E+01
.143E+01	.794E+03	.110E+01	.568E-01	.383E+00	.197E-01	.384E+00	.295E+01	.110E+01
.161E+01	.891E+03	.111E+01	.544E-01	.385E+00	.189E-01	.386E+00	.281E+01	.111E+01
.181E+01	.100E+04	.111E+01	.515E-01	.387E+00	.179E-01	.388E+00	.264E+01	.112E+01
.203E+01	.112E+04	.112E+01	.481E-01	.389E+00	.167E-01	.389E+00	.246E+01	.112E+01
.227E+01	.126E+04	.113E+01	.443E-01	.391E+00	.154E-01	.391E+00	.226E+01	.113E+01
.255E+01	.141E+04	.113E+01	.402E-01	.393E+00	.140E-01	.393E+00	.204E+01	.113E+01
.286E+01	.158E+04	.113E+01	.357E-01	.394E+00	.124E-01	.394E+00	.180E+01	.114E+01
.321E+01	.178E+04	.114E+01	.308E-01	.395E+00	.107E-01	.396E+00	.155E+01	.114E+01
.360E+01	.200E+04	.114E+01	.256E-01	.397E+00	.889E-02	.397E+00	.128E+01	.114E+01
.404E+01	.224E+04	.115E+01	.201E-01	.398E+00	.697E-02	.398E+00	.100E+01	.115E+01
.453E+01	.251E+04	.115E+01	.143E-01	.399E+00	.495E-02	.399E+00	.712E+00	.115E+01
.509E+01	.282E+04	.115E+01	.817E-02	.399E+00	.284E-02	.399E+00	.407E+00	.115E+01
.571E+01	.316E+04	.115E+01	.182E-02	.400E+00	.633E-03	.400E+00	.907E-01	.115E+01
.641E+01	.355E+04	.115E+01	-.476E-02	.400E+00	-.165E-02	.400E+00	-.237E+00	.115E+01
.719E+01	.398E+04	.115E+01	-.116E-01	.400E+00	-.402E-02	.400E+00	-.575E+00	.115E+01
.806E+01	.447E+04	.115E+01	-.186E-01	.400E+00	-.646E-02	.400E+00	-.924E+00	.115E+01
.905E+01	.501E+04	.115E+01	-.258E-01	.400E+00	-.897E-02	.400E+00	-.128E+01	.115E+01
.102E+02	.562E+04	.115E+01	-.332E-01	.400E+00	-.115E-01	.400E+00	-.165E+01	.115E+01
.114E+02	.631E+04	.115E+01	-.408E-01	.399E+00	-.142E-01	.399E+00	-.203E+01	.115E+01
.128E+02	.708E+04	.115E+01	-.485E-01	.398E+00	-.169E-01	.398E+00	-.242E+01	.115E+01
.143E+02	.794E+04	.114E+01	-.564E-01	.397E+00	-.196E-01	.397E+00	-.283E+01	.114E+01
.161E+02	.891E+04	.114E+01	-.644E-01	.396E+00	-.224E-01	.396E+00	-.324E+01	.114E+01
.181E+02	.100E+05	.113E+01	-.725E-01	.394E+00	-.252E-01	.395E+00	-.366E+01	.114E+01
.203E+02	.112E+05	.113E+01	-.808E-01	.392E+00	-.281E-01	.393E+00	-.409E+01	.113E+01
.227E+02	.126E+05	.112E+01	-.891E-01	.390E+00	-.310E-01	.391E+00	-.454E+01	.113E+01
.255E+02	.141E+05	.112E+01	-.975E-01	.388E+00	-.339E-01	.389E+00	-.499E+01	.112E+01
.286E+02	.158E+05	.111E+01	-.106E+00	.385E+00	-.368E-01	.387E+00	-.546E+01	.111E+01
.321E+02	.178E+05	.110E+01	-.115E+00	.383E+00	-.398E-01	.385E+00	-.594E+01	.111E+01
.360E+02	.200E+05	.109E+01	-.123E+00	.380E+00	-.428E-01	.382E+00	-.643E+01	.110E+01
.404E+02	.224E+05	.108E+01	-.132E+00	.376E+00	-.457E-01	.379E+00	-.693E+01	.109E+01
.453E+02	.251E+05	.107E+01	-.140E+00	.373E+00	-.487E-01	.376E+00	-.745E+01	.108E+01
.509E+02	.282E+05	.106E+01	-.149E+00	.369E+00	-.517E-01	.373E+00	-.797E+01	.107E+01
.571E+02	.316E+05	.105E+01	-.157E+00	.365E+00	-.546E-01	.369E+00	-.851E+01	.106E+01
.641E+02	.355E+05	.104E+01	-.166E+00	.361E+00	-.576E-01	.365E+00	-.907E+01	.105E+01
.719E+02	.398E+05	.103E+01	-.174E+00	.356E+00	-.605E-01	.361E+00	-.963E+01	.104E+01
.806E+02	.447E+05	.101E+01	-.182E+00	.351E+00	-.633E-01	.357E+00	-.102E+02	.103E+01
.905E+02	.501E+05	.997E+00	-.190E+00	.346E+00	-.661E-01	.353E+00	-.108E+02	.102E+01
.102E+03	.562E+05	.982E+00	-.198E+00	.341E+00	-.688E-01	.348E+00	-.114E+02	.100E+01
.114E+03	.631E+05	.966E+00	-.206E+00	.336E+00	-.715E-01	.343E+00	-.120E+02	.988E+00
.128E+03	.708E+05	.950E+00	-.213E+00	.330E+00	-.740E-01	.338E+00	-.126E+02	.973E+00
.143E+03	.794E+05	.932E+00	-.220E+00	.324E+00	-.765E-01	.333E+00	-.133E+02	.958E+00
.161E+03	.891E+05	.914E+00	-.227E+00	.318E+00	-.788E-01	.327E+00	-.139E+02	.942E+00
.181E+03	.100E+06	.896E+00	-.233E+00	.311E+00	-.810E-01	.322E+00	-.146E+02	.926E+00

K. SAMPLE CASE 9

This case is the final velocity coupled response calculations. This is based on the Lengelle method incorporating the Denison and Baum pressure coupled response function. Therefore, the first portion of the output represents the pressure coupled response for this propellant formulation. This is then followed by the velocity coupled information. Again, the propellant oxidizer distribution is unimodal with a mean diameter of 40 microns and a mode width parameter equal to one. The oxidizer mass fraction is equal to .88 and all other default values are assumed. The crossflow velocity is taken to be 20000 centimeters per second. Again, output corresponding to the perturbation in the crossflow velocity is presented.

```
$FLAG $

$PARMST $

$PROPDT $

$ALUMDT $

$EROSDT UINF=20000. $

$RESPDT IRVDB=1 $

$OXDIST DBARI(1)=40., SIGMAI(1)=1.0, ALFAI(1)=.88, MODES=1 $
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Figure 11. Data Deck for Sample Case Number 9.

***** PETITE ENSEMBLE MODEL(PEM) INPUT/OUTPUT PARAMETERS *****

TZERO-INITIAL SOLID PROPELLANT TEMPERATURE	294.15	KELVIN			
XALFA-OXIDIZER TOTAL MASS FRACTION	.8800		NPROP-PROPELLANT NUMBER	0	
AOXID-OXIDIZER TYPE	AP		AFUEL-FUEL BINDER TYPE	HTPB	
QL-OXIDIZER HEAT OF DECOMPOSITION	0.00	CAL/GRAM	QFUEL-FUEL HEAT OF PYROLYSIS	433.00	CAL/GRAM
RHOX-OXIDIZER DENSITY	1.950	G/CM**3	RHOF-FUEL DENSITY	.920	G/CM**3
AOX-OXIDIZER DECOMPOSITION FREQ. FACTOR	.166E+05	G/CM**2-S	AF-FUEL PYROLYSIS FREQUENCY FACTOR	.299E+03	G/CM**2-S
EOX-OXIDIZER DECOMPOSITION ACTIV. ENERGY	21000.	CAL/MOLE	EF-FUEL PYROLYSIS ACTIVATION ENERGY	16900.	CAL/MOLE
AAP-OXIDIZER FLAME FREQUENCY FACTOR	2500000.	CM3-G/S-A	APF-PRIMARY FLAME FREQUENCY FACTOR	1400.	CM3-G/S-A
EAP-OXIDIZER FLAME ACTIVATION ENERGY	25000.	CAL/MOLE	EPF-PRIMARY FLAME ACTIVATION ENERGY	15000.	CAL/MOLE
DELAP-OXIDIZER FLAME REACTION ORDER	1.0		DELPF-PRIMARY FLAME REACTION ORDER	1.5	
PFMW-PRIMARY FLAME M.W. (1000 PSIA)	25.99	G/GMOLE	XNUPF-PRIMARY FLAME STOICHIOMETRY VARIABLE	9.30	
FFMW-FINAL FLAME M.W. (1000 PSIA)	26.95	G/GMOLE	XNUFF-FINAL FLAME STOICHIOMETRY VARIABLE	9.30	
CP-GAS PHASE SPECIFIC HEAT CAPACITY	.40	CAL/G-K	CIGN-IGNITION DELAY PROPORTIONALITY VALUE	190.	S-ATM/CM
XLAMB-GAS PHASE THERMAL CONDUCTIVITY	.50000E-05	CAL/CM-S-K	POWD-IGNITION DELAY DIAMETER EXPONENT	.800	
GAMMA-DIFFUSION COEFFICIENT PARAMETER	.760E-05	CM2-A/S-K	POWIG-IGNITION DELAY PRESSURE EXPONENT	.721	
PLAMB-SOLID PHASE THERMAL CONDUCTIVITY	.00030	CAL/CM-S-K	CS-SOLID PHASE SPECIFIC HEAT	.20	
FACTOR-FLAME TEMPERATURE PARAMETER	.50				

PSTART-STARTING PRESSURE (RATE/PRESSURE)	68.0272	ATMS	LIMBES-NUMBER OF TERMS (BURKE SCHUMANN)	40
PSTOP-STOPPING PRESSURE (RATE/PRESSURE)	68.0272	ATMS	ERRBES-MINIMUM VALUE OF LAST TERM IN SERIES	.100E-06
NPRESS-NUMBER OF PRESSURES CONSIDERED	1		ESTART-INITIAL N.D. DIFFUSION HEIGHT	.100E+00
NDPM-NUMBER OF DIAMETERS/MODE-(RATE CAL.)	21		XHUHI-MAX VOLUME FRACTION (BURKE SCHUMANN)	.980
NXDPM-NUMBER OF DIAMETERS/MODE-(C-CAL.)	201		XHULOW-MIN VOLUME FRACTION (BURKE SCHUMANN)	.300
UINF-CROSS FLOW VELOCITY-EROSIVE BURNING	20000.	CM/SEC	CPRIME-CONSTANT IN PRANDTL MIXING LENGTH EXP.	.16
YSTART-STARTING VALUE OF Y-COORDINATE(CM)	0.000000		COND-PROP. CONST.-DIFFUSION COEFFICIENT	1.00
YSTOP-STOPPING VALUE OF Y-COORDINATE(CM)	1.000000		CONC-PROP. CONST.-THERMAL CONDUCTIVITY	1.00
NSTEP-NUMBER OF STEPS-TURB. VEL. PROFILE	461		ITERO-NUMBER OF EROSIVE BURNING ITERATIONS	20
INSTEP-STEPS/UNIT LN10(Y-COORDINATE)	100		NCYC-NUMBER OF LOG10 CYCLES USED	5

			***** METAL PARAMETERS *****		
PPERD-PRESSURE PERTURBATION (NONSTEADY)	.50	PERCENT			
TPERD-TEMPERATURE PERTURBATION (NONSTEADY)	.50	PERCENT	ALTYPE-ALUMINUM TYPE	NONE	
BFAC-COHEN POSTULATE CONSTANT (MAGNITUDE)	1360.000	MICRON	BETA-MASS FRACTION OF METAL	0.0000	
FFAC-COHEN POSTULATE CONSTANT (FREQUENCY)	4.720		QM-LATENT HEAT OF METAL LIQUIFACTION	96.00	CAL/GRAM
OSTART-STARTING FREQUENCY (NONS. RESPONSE)	10.	HERTZ	RHOM-METAL DENSITY	2.710	G/CM**3
OSTOP-STOPPING FREQUENCY (NONS. RESPONSE)	100000.	HERTZ	DBARM-MEAN DIAMETER OF METAL DISTRIBUTION	6.000	MICRON
NOMEG-NUMBER OF FREQUENCIES CONSIDERED	81		SIGMAM-WIDTH PARAMETER OF METAL DISTRIBUTION	1.0000	

***** CATALYST PARAMETERS *****			***** ADDITIVE PARAMETERS *****	
CATYPE-CATALYST TYPE	NONE			
ALFCAT-MASS FRACTION OF CATALYST	0.0000		ADTYPE-ADDITIVE 1 TYPE	NONE
SPSUR-SPECIFIC SURFACE OF CATALYST	0.0000	M**2/GRAM	ALFADD-ADDITIVE 1 MASS FRACTION	0.0000
CAP-AP FLAME FACTOR (EXPONENTIAL)	0.00			
EAP2-AP FLAME FACTOR (ACT. ENERGY)	0.00	CAL/MOLE	ADTYPE-ADDITIVE 2 TYPE	NONE
CPF-PF FLAME FACTOR (EXPONENTIAL)	14.96		ALFADD-ADDITIVE 2 MASS FRACTION	0.0000
EPF2-PF FLAME FACTOR (ACT. ENERGY)	2610.00	CAL/MOLE		

XNUT-OXIDIZER VOLUME FRACTION	.77578		CX-VALUE OF C IN VF=C*DZERO**N EXPRESS.	.151E+00
RHOT-TOTAL PROPELLANT DENSITY	1.71905	G/CM**3	XN-VALUE OF N IN VF=C*DZERO**N EXPRESS.	3.000
RHOFA-FUEL-ALUMINUM MIXTURE DENSITY	.92000	G/CM**3	MODES-NUMBER OF OXIDIZER MODES	1

MODE NUMBER	MEAN DIAMETER (DBARI)	MODE WIDTH PARAMETER (SIGMAI)	MASS FRACTION (ALFAI)	MASS FRACTION (CORR)
1	40.000	1.0000	.8800	

PRESSURE IS 1000.0 PSIA   THE OXID/FUEL BEING CONSIDERED IS   AP/ HTPB
INITIAL PROPELLANT TEMPERATURE IS 294.2 DEGREES KELVIN

DZERO (MICRONS)	BETAF	XSTPD (MICRONS)	XSTPF (MICRONS)	XSTAP (MICRONS)	XSTFD (MICRONS)	TF (K)	TS (K)	TSPF ...	TSFF (PERCENT)	TSAP ...	TSQL (K)	TSQF (K)	TSQM (K)	SDXP
40.00	.028	24.207	.354	1.029	23.138	2998.3	1107.14	9.62	23.78	66.61	0.00	-295.23	0.00	2.145

DZERO (MICRONS)	RATE (CM/SEC)	XNUV	ALFAV	RHOV (G/CM**3)	FSKP	XLAMAP (CAL/CM-S-K)	XLAMPF (CAL/CM-S-K)	XLAMFF (CAL/CM-S-K)
40.00	1.3055	.7758	.8800	1.7190	0.0000	.1772E-03	.2265E-03	.2265E-03

MODE NUMBER 1   SERIES RATE = 1.3055 CM/SEC   PARALLEL RATE = 1.3055 CM/SEC   BETAR =   .3055

*** DENISON AND BAUM PRESSURE COUPLED RESPONSE CALCULATIONS ***

	DZERO (MICRONS)	RATE (CM/SEC)	A-DENISON AND BAUM	B-DENISON AND BAUM	PRESSURE EXPONENT	ITERA	R(P-PPERD) (CM/SEC)	R(P+PPERD) (CM/SEC)	ES1	ES2	AVV
1	40.000	1.3055	6.783605	.54407834	.3404014	2	1.3033	1.3077	0.00	0.00	0.00000

NDF	OMEGA (CPS)	RE(RSP/N)	IM(RSP/N)	RE(RSP)	IM(RSP)	MAG(RSP)	PHASE (DEGREES)	MAG(RSP/N)
.322E-01	.100E+02	.100E+01	.503E-01	.341E+00	.171E-01	.341E+00	.288E+01	.100E+01
.361E-01	.112E+02	.100E+01	.565E-01	.341E+00	.192E-01	.341E+00	.323E+01	.100E+01
.405E-01	.126E+02	.100E+01	.633E-01	.341E+00	.216E-01	.342E+00	.362E+01	.100E+01
.454E-01	.141E+02	.100E+01	.710E-01	.341E+00	.242E-01	.342E+00	.406E+01	.100E+01
.510E-01	.158E+02	.100E+01	.797E-01	.341E+00	.271E-01	.342E+00	.454E+01	.101E+01
.572E-01	.178E+02	.100E+01	.893E-01	.341E+00	.304E-01	.343E+00	.509E+01	.101E+01
.642E-01	.200E+02	.100E+01	.100E+00	.342E+00	.341E-01	.343E+00	.569E+01	.101E+01
.720E-01	.224E+02	.100E+01	.112E+00	.342E+00	.382E-01	.344E+00	.637E+01	.101E+01
.808E-01	.251E+02	.101E+01	.126E+00	.342E+00	.428E-01	.345E+00	.712E+01	.101E+01
.907E-01	.282E+02	.101E+01	.141E+00	.343E+00	.479E-01	.346E+00	.795E+01	.102E+01
.102E+00	.316E+02	.101E+01	.158E+00	.344E+00	.537E-01	.348E+00	.888E+01	.102E+01
.114E+00	.355E+02	.101E+01	.176E+00	.344E+00	.600E-01	.350E+00	.989E+01	.103E+01
.128E+00	.398E+02	.101E+01	.197E+00	.345E+00	.671E-01	.352E+00	.110E+02	.103E+01
.144E+00	.447E+02	.102E+01	.220E+00	.346E+00	.750E-01	.355E+00	.122E+02	.104E+01
.161E+00	.501E+02	.102E+01	.246E+00	.348E+00	.838E-01	.358E+00	.135E+02	.105E+01
.181E+00	.562E+02	.103E+01	.275E+00	.350E+00	.935E-01	.362E+00	.150E+02	.106E+01
.203E+00	.631E+02	.103E+01	.306E+00	.352E+00	.104E+00	.367E+00	.165E+02	.108E+01
.228E+00	.708E+02	.104E+01	.341E+00	.354E+00	.116E+00	.373E+00	.181E+02	.109E+01
.256E+00	.794E+02	.105E+01	.379E+00	.357E+00	.129E+00	.380E+00	.199E+02	.112E+01
.287E+00	.891E+02	.106E+01	.421E+00	.360E+00	.143E+00	.388E+00	.217E+02	.114E+01
.322E+00	.100E+03	.107E+01	.468E+00	.364E+00	.159E+00	.397E+00	.236E+02	.117E+01
.361E+00	.112E+03	.108E+01	.518E+00	.369E+00	.176E+00	.409E+00	.256E+02	.120E+01
.405E+00	.126E+03	.110E+01	.574E+00	.374E+00	.195E+00	.422E+00	.276E+02	.124E+01
.454E+00	.141E+03	.112E+01	.635E+00	.380E+00	.216E+00	.437E+00	.297E+02	.128E+01
.510E+00	.158E+03	.113E+01	.703E+00	.386E+00	.239E+00	.454E+00	.318E+02	.133E+01
.572E+00	.178E+03	.116E+01	.777E+00	.393E+00	.265E+00	.474E+00	.339E+02	.139E+01

.642E+00	.200E+03	.118E+01	.860E+00	.402E+00	.293E+00	.497E+00	.361E+02	.146E+01
.720E+00	.224E+03	.121E+01	.951E+00	.411E+00	.324E+00	.523E+00	.382E+02	.154E+01
.808E+00	.251E+03	.124E+01	.105E+01	.422E+00	.358E+00	.553E+00	.404E+02	.163E+01
.907E+00	.282E+03	.127E+01	.117E+01	.433E+00	.397E+00	.588E+00	.425E+02	.173E+01
.102E+01	.316E+03	.131E+01	.130E+01	.447E+00	.441E+00	.628E+00	.446E+02	.184E+01
.114E+01	.355E+03	.136E+01	.144E+01	.462E+00	.491E+00	.675E+00	.467E+02	.198E+01
.128E+01	.398E+03	.141E+01	.161E+01	.481E+00	.548E+00	.729E+00	.488E+02	.214E+01
.144E+01	.447E+03	.148E+01	.181E+01	.502E+00	.615E+00	.794E+00	.508E+02	.233E+01
.161E+01	.501E+03	.155E+01	.204E+01	.529E+00	.693E+00	.872E+00	.527E+02	.256E+01
.181E+01	.562E+03	.165E+01	.231E+01	.561E+00	.787E+00	.967E+00	.545E+02	.284E+01
.203E+01	.631E+03	.177E+01	.265E+01	.604E+00	.901E+00	.109E+01	.562E+02	.319E+01
.228E+01	.708E+03	.194E+01	.307E+01	.662E+00	.104E+01	.124E+01	.576E+02	.363E+01
.256E+01	.794E+03	.219E+01	.362E+01	.745E+00	.123E+01	.144E+01	.588E+02	.423E+01
.287E+01	.891E+03	.256E+01	.436E+01	.871E+00	.148E+01	.172E+01	.596E+02	.505E+01
.322E+01	.100E+04	.319E+01	.541E+01	.109E+01	.184E+01	.214E+01	.595E+02	.628E+01
.361E+01	.112E+04	.442E+01	.702E+01	.150E+01	.239E+01	.283E+01	.578E+02	.830E+01
.405E+01	.126E+04	.741E+01	.960E+01	.252E+01	.327E+01	.413E+01	.523E+02	.121E+02
.454E+01	.141E+04	.172E+02	.118E+02	.586E+01	.402E+01	.710E+01	.345E+02	.209E+02
.510E+01	.158E+04	.274E+02	-.109E+02	.933E+01	-.370E+01	.100E+02	-.216E+02	.295E+02
.572E+01	.178E+04	.743E+01	-.150E+02	.253E+01	-.510E+01	.569E+01	-.636E+02	.167E+02
.642E+01	.200E+04	.250E+01	-.977E+01	.850E+00	-.332E+01	.343E+01	-.757E+02	.101E+02
.720E+01	.224E+04	.126E+01	-.691E+01	.430E+00	-.235E+01	.239E+01	-.796E+02	.702E+01
.808E+01	.251E+04	.844E+00	-.525E+01	.287E+00	-.179E+01	.181E+01	-.809E+02	.532E+01
.907E+01	.282E+04	.669E+00	-.419E+01	.228E+00	-.143E+01	.144E+01	-.809E+02	.424E+01
.102E+02	.316E+04	.585E+00	-.345E+01	.199E+00	-.118E+01	.119E+01	-.804E+02	.350E+01
.114E+02	.355E+04	.540E+00	-.291E+01	.184E+00	-.992E+00	.101E+01	-.795E+02	.296E+01
.128E+02	.398E+04	.511E+00	-.250E+01	.174E+00	-.851E+00	.869E+00	-.784E+02	.255E+01
.144E+02	.447E+04	.491E+00	-.217E+01	.167E+00	-.739E+00	.758E+00	-.773E+02	.223E+01
.161E+02	.501E+04	.474E+00	-.191E+01	.161E+00	-.649E+00	.669E+00	-.760E+02	.196E+01
.181E+02	.562E+04	.459E+00	-.169E+01	.156E+00	-.574E+00	.595E+00	-.748E+02	.175E+01
.203E+02	.631E+04	.445E+00	-.150E+01	.151E+00	-.511E+00	.533E+00	-.735E+02	.156E+01
.228E+02	.708E+04	.430E+00	-.134E+01	.146E+00	-.457E+00	.480E+00	-.722E+02	.141E+01
.256E+02	.794E+04	.416E+00	-.121E+01	.142E+00	-.410E+00	.434E+00	-.710E+02	.128E+01
.287E+02	.891E+04	.401E+00	-.109E+01	.136E+00	-.370E+00	.394E+00	-.698E+02	.116E+01
.322E+02	.100E+05	.386E+00	-.984E+00	.131E+00	-.335E+00	.360E+00	-.686E+02	.106E+01
.361E+02	.112E+05	.371E+00	-.892E+00	.126E+00	-.304E+00	.329E+00	-.674E+02	.967E+00
.405E+02	.126E+05	.356E+00	-.812E+00	.121E+00	-.276E+00	.302E+00	-.663E+02	.886E+00
.454E+02	.141E+05	.341E+00	-.740E+00	.116E+00	-.252E+00	.277E+00	-.653E+02	.815E+00
.510E+02	.158E+05	.326E+00	-.676E+00	.111E+00	-.230E+00	.255E+00	-.642E+02	.750E+00
.572E+02	.178E+05	.312E+00	-.618E+00	.106E+00	-.210E+00	.236E+00	-.632E+02	.692E+00
.642E+02	.200E+05	.297E+00	-.567E+00	.101E+00	-.193E+00	.218E+00	-.623E+02	.640E+00
.720E+02	.224E+05	.284E+00	-.520E+00	.965E-01	-.177E+00	.202E+00	-.614E+02	.592E+00
.808E+02	.251E+05	.270E+00	-.478E+00	.919E-01	-.163E+00	.187E+00	-.605E+02	.549E+00
.907E+02	.282E+05	.257E+00	-.440E+00	.874E-01	-.150E+00	.173E+00	-.597E+02	.509E+00
.102E+03	.316E+05	.244E+00	-.405E+00	.831E-01	-.138E+00	.161E+00	-.589E+02	.473E+00
.114E+03	.355E+05	.232E+00	-.374E+00	.790E-01	-.127E+00	.150E+00	-.582E+02	.440E+00
.128E+03	.398E+05	.220E+00	-.346E+00	.750E-01	-.118E+00	.139E+00	-.575E+02	.410E+00
.144E+03	.447E+05	.209E+00	-.320E+00	.711E-01	-.109E+00	.130E+00	-.568E+02	.382E+00
.161E+03	.501E+05	.198E+00	-.296E+00	.674E-01	-.101E+00	.121E+00	-.562E+02	.356E+00
.181E+03	.562E+05	.188E+00	-.274E+00	.639E-01	-.933E-01	.113E+00	-.556E+02	.332E+00
.203E+03	.631E+05	.178E+00	-.254E+00	.606E-01	-.865E-01	.106E+00	-.550E+02	.310E+00
.228E+03	.708E+05	.168E+00	-.236E+00	.573E-01	-.803E-01	.987E-01	-.545E+02	.290E+00
.256E+03	.794E+05	.160E+00	-.219E+00	.543E-01	-.746E-01	.922E-01	-.539E+02	.271E+00
.287E+03	.891E+05	.151E+00	-.204E+00	.514E-01	-.693E-01	.863E-01	-.535E+02	.254E+00
.322E+03	.100E+06	.143E+00	-.190E+00	.486E-01	-.645E-01	.808E-01	-.530E+02	.237E+00

*** LENGELLE VELOCITY COUPLED RESPONSE CALCULATIONS ***

	DZERO (MICRONS)	RATE (CM/SEC)	PXNE	R(U-UPERD) (CM/SEC)	(U+UPERD)) (CM/SEC)
1	40.000	1.7427	.34737	1.7396	1.7457

NDF	OMEGA (CPS)	RE(RSP/N)	IM(RSP/N)	RE(RSP)	IM(RSP)	MAG(RSP)	PHASE (DEGREES)	MAG(RSP/N)
.181E-01	.100E+02	-.161E+02	-.239E+02	-.558E+01	-.831E+01	.100E+02	-.124E+03	.288E+02
.203E-01	.112E+02	-.135E+02	-.230E+02	-.470E+01	-.798E+01	.926E+01	-.121E+03	.267E+02
.227E-01	.126E+02	-.112E+02	-.218E+02	-.390E+01	-.757E+01	.852E+01	-.117E+03	.245E+02
.255E-01	.141E+02	-.919E+01	-.205E+02	-.319E+01	-.712E+01	.780E+01	-.114E+03	.225E+02
.286E-01	.158E+02	-.740E+01	-.191E+02	-.257E+01	-.663E+01	.711E+01	-.111E+03	.205E+02
.321E-01	.178E+02	-.585E+01	-.177E+02	-.203E+01	-.613E+01	.646E+01	-.108E+03	.186E+02
.360E-01	.200E+02	-.454E+01	-.162E+02	-.158E+01	-.563E+01	.585E+01	-.106E+03	.168E+02
.404E-01	.224E+02	-.344E+01	-.148E+02	-.119E+01	-.515E+01	.528E+01	-.103E+03	.152E+02
.453E-01	.251E+02	-.252E+01	-.135E+02	-.877E+00	-.468E+01	.476E+01	-.101E+03	.137E+02
.509E-01	.282E+02	-.177E+01	-.122E+02	-.615E+00	-.424E+01	.429E+01	-.983E+02	.123E+02
.571E-01	.316E+02	-.116E+01	-.110E+02	-.402E+00	-.383E+01	.385E+01	-.960E+02	.111E+02
.641E-01	.355E+02	-.657E+00	-.994E+01	-.228E+00	-.345E+01	.346E+01	-.938E+02	.996E+01
.719E-01	.398E+02	-.253E+00	-.894E+01	-.878E-01	-.310E+01	.311E+01	-.916E+02	.894E+01
.806E-01	.447E+02	.727E-01	-.803E+01	.253E-01	-.279E+01	.279E+01	-.895E+02	.803E+01
.905E-01	.501E+02	.334E+00	-.720E+01	.116E+00	-.250E+01	.250E+01	-.873E+02	.721E+01
.102E+00	.562E+02	.542E+00	-.645E+01	.188E+00	-.224E+01	.225E+01	-.852E+02	.648E+01
.114E+00	.631E+02	.708E+00	-.578E+01	.246E+00	-.201E+01	.202E+01	-.830E+02	.583E+01
.128E+00	.708E+02	.840E+00	-.518E+01	.292E+00	-.180E+01	.182E+01	-.808E+02	.525E+01
.143E+00	.794E+02	.944E+00	-.464E+01	.328E+00	-.161E+01	.164E+01	-.785E+02	.473E+01
.161E+00	.891E+02	.103E+01	-.415E+01	.356E+00	-.144E+01	.149E+01	-.761E+02	.428E+01
.181E+00	.100E+03	.109E+01	-.372E+01	.378E+00	-.129E+01	.135E+01	-.737E+02	.388E+01
.203E+00	.112E+03	.114E+01	-.333E+01	.395E+00	-.116E+01	.122E+01	-.712E+02	.352E+01
.227E+00	.126E+03	.117E+01	-.299E+01	.407E+00	-.104E+01	.112E+01	-.686E+02	.321E+01
.255E+00	.141E+03	.120E+01	-.268E+01	.416E+00	-.932E+00	.102E+01	-.659E+02	.294E+01
.286E+00	.158E+03	.122E+01	-.241E+01	.423E+00	-.836E+00	.937E+00	-.632E+02	.270E+01
.321E+00	.178E+03	.123E+01	-.216E+01	.427E+00	-.751E+00	.864E+00	-.604E+02	.249E+01

.360E+00	.200E+03	.123E+01	-.194E+01	.429E+00	-.675E+00	.800E+00	-.576E+02	.230E+01
.404E+00	.224E+03	.124E+01	-.175E+01	.429E+00	-.607E+00	.744E+00	-.548E+02	.214E+01
.453E+00	.251E+03	.123E+01	-.157E+01	.429E+00	-.547E+00	.695E+00	-.519E+02	.200E+01
.509E+00	.282E+03	.123E+01	-.142E+01	.427E+00	-.492E+00	.652E+00	-.491E+02	.188E+01
.571E+00	.316E+03	.122E+01	-.128E+01	.425E+00	-.443E+00	.614E+00	-.462E+02	.177E+01
.641E+00	.355E+03	.121E+01	-.115E+01	.421E+00	-.399E+00	.581E+00	-.434E+02	.167E+01
.719E+00	.398E+03	.120E+01	-.103E+01	.418E+00	-.359E+00	.551E+00	-.407E+02	.159E+01
.806E+00	.447E+03	.119E+01	-.931E+00	.414E+00	-.323E+00	.526E+00	-.380E+02	.151E+01
.905E+00	.501E+03	.118E+01	-.837E+00	.410E+00	-.291E+00	.503E+00	-.353E+02	.145E+01
.102E+01	.562E+03	.117E+01	-.751E+00	.406E+00	-.261E+00	.483E+00	-.327E+02	.139E+01
.114E+01	.631E+03	.116E+01	-.672E+00	.402E+00	-.233E+00	.465E+00	-.301E+02	.134E+01
.128E+01	.708E+03	.115E+01	-.599E+00	.398E+00	-.208E+00	.449E+00	-.276E+02	.129E+01
.143E+01	.794E+03	.113E+01	-.532E+00	.394E+00	-.185E+00	.435E+00	-.251E+02	.125E+01
.161E+01	.891E+03	.112E+01	-.470E+00	.390E+00	-.163E+00	.423E+00	-.227E+02	.122E+01
.181E+01	.100E+04	.111E+01	-.412E+00	.386E+00	-.143E+00	.412E+00	-.203E+02	.119E+01
.203E+01	.112E+04	.110E+01	-.357E+00	.383E+00	-.124E+00	.402E+00	-.180E+02	.116E+01
.227E+01	.126E+04	.109E+01	-.306E+00	.379E+00	-.106E+00	.394E+00	-.156E+02	.113E+01
.255E+01	.141E+04	.108E+01	-.256E+00	.376E+00	-.891E-01	.386E+00	-.133E+02	.111E+01
.286E+01	.158E+04	.107E+01	-.209E+00	.373E+00	-.726E-01	.380E+00	-.110E+02	.109E+01
.321E+01	.178E+04	.107E+01	-.163E+00	.370E+00	-.567E-01	.374E+00	-.871E+01	.108E+01
.360E+01	.200E+04	.106E+01	-.118E+00	.367E+00	-.411E-01	.370E+00	-.639E+01	.106E+01
.404E+01	.224E+04	.105E+01	-.745E-01	.364E+00	-.259E-01	.365E+00	-.406E+01	.105E+01
.453E+01	.251E+04	.104E+01	-.308E-01	.362E+00	-.107E-01	.362E+00	-.169E+01	.104E+01
.509E+01	.282E+04	.103E+01	.128E-01	.359E+00	.446E-02	.359E+00	.713E+00	.103E+01
.571E+01	.316E+04	.102E+01	.568E-01	.356E+00	.197E-01	.357E+00	.317E+01	.103E+01
.641E+01	.355E+04	.102E+01	.101E+00	.353E+00	.352E-01	.355E+00	.570E+01	.102E+01
.719E+01	.398E+04	.101E+01	.147E+00	.349E+00	.510E-01	.353E+00	.831E+01	.102E+01
.806E+01	.447E+04	.994E+00	.193E+00	.345E+00	.671E-01	.352E+00	.110E+02	.101E+01
.905E+01	.501E+04	.980E+00	.241E+00	.340E+00	.837E-01	.351E+00	.138E+02	.101E+01
.102E+02	.562E+04	.964E+00	.290E+00	.335E+00	.101E+00	.350E+00	.167E+02	.101E+01
.114E+02	.631E+04	.944E+00	.340E+00	.328E+00	.118E+00	.349E+00	.198E+02	.100E+01
.128E+02	.708E+04	.921E+00	.391E+00	.320E+00	.136E+00	.347E+00	.230E+02	.100E+01
.143E+02	.794E+04	.892E+00	.443E+00	.310E+00	.154E+00	.346E+00	.264E+02	.996E+00
.161E+02	.891E+04	.859E+00	.494E+00	.298E+00	.172E+00	.344E+00	.299E+02	.991E+00
.181E+02	.100E+05	.819E+00	.544E+00	.285E+00	.189E+00	.342E+00	.336E+02	.984E+00
.203E+02	.112E+05	.773E+00	.592E+00	.269E+00	.206E+00	.338E+00	.374E+02	.974E+00
.227E+02	.126E+05	.721E+00	.637E+00	.250E+00	.221E+00	.334E+00	.415E+02	.962E+00
.255E+02	.141E+05	.662E+00	.676E+00	.230E+00	.235E+00	.329E+00	.456E+02	.946E+00
.286E+02	.158E+05	.597E+00	.708E+00	.208E+00	.246E+00	.322E+00	.498E+02	.926E+00
.321E+02	.178E+05	.529E+00	.732E+00	.184E+00	.254E+00	.314E+00	.542E+02	.903E+00
.360E+02	.200E+05	.457E+00	.747E+00	.159E+00	.260E+00	.304E+00	.585E+02	.876E+00
.404E+02	.224E+05	.385E+00	.753E+00	.134E+00	.261E+00	.294E+00	.629E+02	.845E+00
.453E+02	.251E+05	.314E+00	.748E+00	.109E+00	.260E+00	.282E+00	.672E+02	.812E+00
.509E+02	.282E+05	.246E+00	.735E+00	.856E-01	.255E+00	.269E+00	.715E+02	.775E+00
.571E+02	.316E+05	.183E+00	.714E+00	.637E-01	.248E+00	.256E+00	.756E+02	.737E+00
.641E+02	.355E+05	.127E+00	.686E+00	.439E-01	.238E+00	.242E+00	.795E+02	.697E+00
.719E+02	.398E+05	.764E-01	.653E+00	.266E-01	.227E+00	.228E+00	.833E+02	.657E+00
.806E+02	.447E+05	.334E-01	.617E+00	.116E-01	.214E+00	.215E+00	.869E+02	.618E+00
.905E+02	.501E+05	-.272E-02	.579E+00	-.945E-03	.201E+00	.201E+00	.903E+02	.579E+00
.102E+03	.562E+05	-.323E-01	.540E+00	-.112E-01	.188E+00	.188E+00	.934E+02	.541E+00
.114E+03	.631E+05	-.560E-01	.502E+00	-.195E-01	.174E+00	.175E+00	.964E+02	.505E+00
.128E+03	.708E+05	-.745E-01	.465E+00	-.259E-01	.161E+00	.163E+00	.991E+02	.471E+00
.143E+03	.794E+05	-.884E-01	.429E+00	-.307E-01	.149E+00	.152E+00	.102E+03	.438E+00
.161E+03	.891E+05	-.986E-01	.396E+00	-.343E-01	.137E+00	.142E+00	.104E+03	.408E+00
.181E+03	.100E+06	-.106E+00	.364E+00	-.367E-01	.127E+00	.132E+00	.106E+03	.379E+00

L. SAMPLE CASE 10

This is the final case to be presented. Unlike the other ten cases, this case is the calculation of the pressure coupled response versus frequency for one of the propellants provided by the RPL. The number designation of the propellant considered is 3-1 (17). The oxidizer distribution does not need to be inputed since this information has been previously encoded within the program via subroutine OXDATA. Therefore, one only need to enter NPROP=17 in the OXDIST namelist. The Zeldovich/Novozhilov pressure coupled response method is being employed and response will be calculated at a pressure of 43.5374 atmospheres and an initial solid propellant temperature of 300 K. Unlike the other nonsteady state response calculations, 121 frequencies are being considered with the data written on TAPE7 being plotted along with available experimental data. The formatted input data given for this case represents what is required to plot the results of the nonsteady state calculations. In this case, both of the y axes are being annotated; the right y axis being the value of the normalized pressure coupled response and the left y axis being a factor of .402 less-thus representing the corresponding non-normalized pressure coupled response. The resulting plot is depicted by Figure 13.

```
$FLAG $
$PARMST PSTART=43.5374, PSTOP=43.5374, NPRESS=1, TZERO=300. $
$PROPDT $
$ALUMDT $
$EROSDT $
$RESPDT IRPZN=1, NOMEG=121, NPLOT=7 $
$OXDIST NPROP=17 $
120.      100.       1     0
10.       100000.    4     1      0      0
4.0   3.0         22FREQUENCY (CYCLES/SEC)
0.0       5.0        5     0      4      F4.1
3.0   3.0         10REAL(RP/N)
0.0       2.01       5     0      4      F4.1
3.0   3.0         8REAL(RP)
0.0       50.
02
75. 90. 3.0 0.0  11RPL 3-1(17)
75. 84. 3.0 0.0  144.41 MPA/300 K
    1
    0    0    0    1   121   3   7
    4
    0   -1    0    0     5   0   0
80.       1.71
120.      2.00
160.      2.23
200.      2.69
300.      2.86
```

Figure 12. Data Deck for Sample Case 10.

```
             *****      PETITE ENSEMBLE MODEL(PEM) INPUT/OUTPUT PARAMETERS      *****

TZERO-INITIAL SOLID PROPELLANT TEMPERATURE       300.00 KELVIN
XALFA-OXIDIZER TOTAL MASS FRACTION                .6980                 NPROP-PROPELLANT NUMBER                              17
NOXID-OXIDIZER TYPE                                  AP                 NFUEL-FUEL BINDER TYPE                             PBAN
   QL-OXIDIZER HEAT OF DECOMPOSITION               0.00 CAL/GRAM        QFUEL-FUEL HEAT OF PYROLYSIS                     433.00 CAL/GRAM
 RHOX-OXIDIZER DENSITY                            1.950 G/CM**3          RHOF-FUEL DENSITY                                 .903 G/CM**3
  AOX-OXIDIZER DECOMPOSITION FREQ. FACTOR      .188E+05 G/CM**2-S          AF-FUEL PYROLYSIS FREQUENCY FACTOR          .299E+03 G/CM**2-S
  EOX-OXIDIZER DECOMPOSITION ACTIV. ENERGY       21000. CAL/MOLE           EF-FUEL PYROLYSIS ACTIVATION ENERGY           16900. CAL/MOLE
  AAP-OXIDIZER FLAME FREQUENCY FACTOR          2500000. CM3-G/S-A         APF-PRIMARY FLAME FREQUENCY FACTOR             1400. CM3-G/S-A
  EAP-OXIDIZER FLAME ACTIVATION ENERGY           25000. CAL/MOLE          EPF-PRIMARY FLAME ACTIVATION ENERGY           14280. CAL/MOLE
DELAP-OXIDIZER FLAME REACTION ORDER                 1.0                 DELPF-PRIMARY FLAME REACTION ORDER                  1.5
 PFMW-PRIMARY FLAME M.W. (1000 PSIA)              28.63 G/GMOLE         XNUPF-PRIMARY FLAME STOICHIOMETRY VARIABLE         9.30
 FFMW-FINAL FLAME M.W. (1000 PSIA)                29.27 G/GMOLE         XNUFF-FINAL FLAME STOICHIOMETRY VARIABLE           9.30
   CP-GAS PHASE SPECIFIC HEAT CAPACITY              .40 CAL/G-K          CIGN-IGNITION DELAY PROPORTIONALITY VALUE         190. S-ATM/CM
XLAMB-GAS PHASE THERMAL CONDUCTIVITY          .50000E-05 CAL/CM-S-K      POWD-IGNITION DELAY DIAMETER EXPONENT             .800
GAMMA-DIFFUSION COEFFICIENT PARAMETER           .760E-05 CM2-A/S-K      POWIG-IGNITION DELAY PRESSURE EXPONENT             .721
PLAMB-SOLID PHASE THERMAL CONDUCTIVITY            .00030 CAL/CM-S-K        CS-SOLID PHASE SPECIFIC HEAT                     .20
FACTOR-FLAME TEMPERATURE PARAMETER                  .50

PSTART-STARTING PRESSURE (RATE/PRESSURE)        43.5374 ATMS           LIMBES-NUMBER OF TERMS (BURKE SCHUMANN)              40
 PSTOP-STOPPING PRESSURE (RATE/PRESSURE)        43.5374 ATMS           ERRBES-MINIMUM VALUE OF LAST TERM IN SERIES    .100E-06
NPRESS-NUMBER OF PRESSURES CONSIDERED                 1                ESTART-INITIAL N.D. DIFFUSION HEIGHT           .100E+00
  NDFM-NUMBER OF DIAMETERS/MODE-(RATE CAL.)          15                 XHUHI-MAX VOLUME FRACTION (BURKE SCHUMANN)         .980
 NXDFM-NUMBER OF DIAMETERS/MODE-(C-CAL.)            141                XHULOW-MIN VOLUME FRACTION (BURKE SCHUMANN)         .300
  UINF-CROSS FLOW VELOCITY-EROSIVE BURNING           0. CM/SEC         CPRIME-CONSTANT IN PRANDTL MIXING LENGTH EXP.        .16
YSTART-STARTING VALUE OF Y-COORDINATE(CM)      0.000000                   COND-PROP. CONST.-DIFFUSION COEFFICIENT          1.00
 YSTOP-STOPPING VALUE OF Y-COORDINATE(CM)      1.000000                   CONC-PROP. CONST.-THERMAL CONDUCTIVITY           1.00
 NSTEP-NUMBER OF STEPS-TURB. VEL. PROFILE           461                 ITERO-NUMBER OF EROSIVE BURNING ITERATIONS          20
INSTEP-STEPS/UNIT LN10(Y-COORDINATE)                100                  NCYC-NUMBER OF LOG10 CYCLES USED                    5

 PPERD-PRESSURE PERTURBATION (NONSTEADY)            .50 PERCENT             *****     METAL PARAMETERS      *****
 TPERD-TEMPERATURE PERTURBATION (NONSTEADY)         .50 PERCENT        ALTYPE-ALUMINUM TYPE                                 AL
  BFAC-COHEN POSTULATE CONSTANT (MAGNITUDE)    1360.000 MICRON           BETA-MASS FRACTION OF METAL                     .1600
  FFAC-COHEN POSTULATE CONSTANT (FREQUENCY)       4.720                    QM-LATENT HEAT OF METAL LIQUIFACTION          96.00 CAL/GRAM
OSTART-STARTING FREQUENCY (NONS. RESPONSE)          10. HERTZ            RHOM-METAL DENSITY                              2.710 G/CM**3
 OSTOP-STOPPING FREQUENCY (NONS. RESPONSE)      100000. HERTZ           DBARM-MEAN DIAMETER OF METAL DISTRIBUTION       18.560 MICRON
 NOMEG-NUMBER OF FREQUENCIES CONSIDERED             121                SIGMAM-WIDTH PARAMETER OF METAL DISTRIBUTION     1.7720

          *****     CATALYST PARAMETERS       *****                         *****     ADDITIVE PARAMETERS      *****
CATYPE-CATALYST TYPE                              FE203
ALFCAT-MASS FRACTION OF CATALYST                  .0040                ADTYPE-ADDITIVE 1 TYPE                             NONE
 SPSUR-SPECIFIC SURFACE OF CATALYST              1.0000 M**2/GRAM      ALFADI-ADDITIVE 1 MASS FRACTION                  0.0000
   CAP-AP FLAME FACTOR (EXPONENTIAL)               0.00
  EAP2-AP FLAME FACTOR (ACT. ENERGY)               0.00 CAL/MOLE       ADTYPE-ADDITIVE 2 TYPE                             NONE
   CPF-PF FLAME FACTOR (EXPONENTIAL)              14.96                ALFADI-ADDITIVE 2 MASS FRACTION                  0.0000
  EPF2-PF FLAME FACTOR (ACT. ENERGY)            2610.00 CAL/MOLE

  XNUT-OXIDIZER VOLUME FRACTION                  .62711                    CX-VALUE OF C IN VF=C*DZERO**N EXPRESS.    .311E+00
  RHOT-TOTAL PROPELLANT DENSITY                 1.75194 G/CM**3            XN-VALUE OF N IN VF=C*DZERO**N EXPRESS.       3.000
 RHOFA-FUEL-ALUMINUM MIXTURE DENSITY            1.41886 G/CM**3         MODES-NUMBER OF OXIDIZER MODES                      2

        MODE    MEAN    MODE WIDTH   MASS     MASS
       NUMBER DIAMETER  PARAMETER  FRACTION FRACTION
               (DBARI)   (SIGMAI)   (ALFAI)   (CORA)

         1     19.010     2.5140     .2094
         2    174.000     1.4040     .4896
```

PRESSURE IS 640.0 PSIA THE OXID/FUEL BEING CONSIDERED IS AP/ PBAN
INITIAL PROPELLANT TEMPERATURE IS 300.0 DEGREES KELVIN

DZERO (MICRONS)	BETAF	XSTPD (MICRONS)	XSTPF (MICRONS)	XSTAP (MICRONS)	XSTFD (MICRONS)	TF (K)	TS (K)	TSPF ...	TSFF (PERCENT)	TSAP ...	TSQL (K)	TSQF (K)	TSQM (K)	SOXP
.62	1.000	.132	1.684	2.474	0.000	2405.8	1137.69	94.33	0.00	0.00	0.00	-440.44	-295.39	2.482
1.01	1.000	.219	1.664	2.445	0.000	2405.8	1136.86	94.32	0.00	0.00	0.00	-440.44	-295.30	2.469
1.64	1.000	.367	1.631	2.397	0.000	2406.8	1135.41	94.24	0.00	0.00	0.00	-440.44	-295.16	2.450
2.68	1.000	.620	1.578	2.318	0.000	2406.8	1132.87	94.10	0.00	0.00	0.00	-440.44	-294.90	2.419
4.38	.640	1.064	1.451	2.131	1.384	2406.8	1125.72	70.18	18.52	7.00	0.00	-440.44	-294.16	2.360
7.14	.336	1.869	1.338	1.966	2.068	2406.8	1119.29	42.97	32.26	16.05	0.00	-440.44	-293.45	2.298
11.65	.168	3.371	1.204	1.768	3.502	2406.8	1110.93	25.39	39.68	25.61	0.00	-440.44	-292.49	2.219
19.01	.079	6.248	1.051	1.544	6.265	2406.8	1100.38	14.22	39.43	36.24	0.00	-440.44	-291.20	2.122
31.01	.035	11.866	.889	1.306	11.659	2406.8	1087.57	7.45	33.70	47.76	0.00	-440.44	-289.54	2.010
50.60	.015	23.118	.738	1.084	22.416	2406.8	1073.87	3.62	25.45	58.72	0.00	-440.44	-287.63	1.829
82.56	.006	46.479	.611	.898	44.618	2406.8	1061.04	1.64	17.36	67.79	0.00	-440.44	-285.74	1.762
134.69	.002	97.092	.512	.752	92.464	2406.8	1050.73	.70	10.77	74.52	0.00	-440.44	-284.15	1.628
219.75	.001	211.271	.437	.642	200.018	2406.8	1044.19	.29	6.11	79.10	0.00	-440.44	-283.10	1.481
358.52	.000	476.055	.380	.559	449.085	2406.8	1041.90	.11	3.22	81.99	0.00	-440.44	-282.73	1.316
584.97	.000	1109.013	.338	.496	1044.263	2406.8	1042.07	.04	1.59	83.71	0.00	-440.44	-282.76	1.168
49.29	.016	22.293	.745	1.095	21.628	2406.8	1074.59	3.77	25.91	58.18	0.00	-440.44	-287.74	1.835
59.03	.011	28.691	.695	1.021	27.725	2406.8	1069.65	2.84	22.80	61.82	0.00	-440.44	-287.02	1.849
70.68	.008	37.097	.643	.952	35.716	2406.8	1064.91	2.12	19.81	65.16	0.00	-440.44	-286.32	1.803
84.63	.006	48.204	.605	.889	46.253	2406.8	1060.45	1.57	16.98	68.19	0.00	-440.44	-285.65	1.755
101.34	.004	62.967	.566	.832	60.230	2406.8	1056.34	1.16	14.38	70.89	0.00	-440.44	-285.02	1.707
121.35	.003	82.705	.531	.780	78.983	2406.8	1052.65	.84	12.02	73.28	0.00	-440.44	-284.45	1.657
145.31	.002	109.241	.499	.733	103.923	2406.8	1049.44	.61	9.92	75.39	0.00	-440.44	-283.94	1.606
174.00	.002	145.101	.470	.691	137.720	2406.8	1046.78	.44	8.09	77.16	0.00	-440.44	-283.52	1.553
208.35	.001	193.772	.444	.653	183.548	2406.8	1044.69	.32	6.53	78.69	0.00	-440.44	-283.19	1.497
249.49	.001	260.046	.421	.619	245.313	2406.8	1043.21	.23	5.21	79.99	0.00	-440.44	-282.95	1.439
298.74	.001	350.510	.400	.587	331.009	2405.8	1042.30	.16	4.12	81.08	0.00	-440.44	-282.80	1.379
357.73	.000	474.265	.380	.559	447.402	2406.8	1041.90	.11	3.23	81.99	0.00	-440.44	-282.73	1.317
428.35	.000	644.197	.363	.533	607.213	2406.8	1041.88	.08	2.52	82.73	0.00	-440.44	-282.73	1.256
512.92	.000	879.467	.347	.510	828.452	2406.8	1042.03	.06	1.94	83.34	0.00	-440.44	-282.75	1.201
614.19	.000	1210.556	.335	.492	1139.714	2406.8	1042.04	.04	1.47	83.83	0.00	-440.44	-282.76	1.158

PRESSURE IS 640.0 PSIA THE OXID/FUEL BEING CONSIDERED IS AP/ PBAN
INITIAL PROPELLANT TEMPERATURE IS 300.0 DEGREES KELVIN

DZERO (MICRONS)	RATE (CM/SEC)	XNUV	ALFAV	RHOV (G/CM**3)	FSKP	XLAMAP (CAL/CM-S-K)	XLAMPF (CAL/CM-S-K)	XLAMFF (CAL/CM-S-K)
.62	1.9518	.6271	.6980	1.7519	.0001	.1782E-03	.2105E-03	.2105E-03
1.01	1.9287	.6271	.6980	1.7519	.0006	.1782E-03	.2105E-03	.2105E-03
1.64	1.8309	.6271	.6980	1.7519	.0027	.1781E-03	.2104E-03	.2104E-03
2.68	1.8289	.6271	.6980	1.7519	.0095	.1780E-03	.2103E-03	.2103E-03
4.38	1.6814	.6271	.6980	1.7519	.0255	.1778E-03	.2101E-03	.2101E-03
7.14	1.5511	.6271	.6980	1.7519	.0516	.1775E-03	.2099E-03	.2099E-03
11.65	1.3949	.6271	.6980	1.7519	.0787	.1772E-03	.2097E-03	.2097E-03
19.01	1.2179	.6271	.6980	1.7519	.0906	.1769E-03	.2094E-03	.2094E-03
31.01	1.0303	.6271	.6980	1.7519	.0737	.1764E-03	.2090E-03	.2090E-03
50.60	.8551	.6271	.6980	1.7519	.0516	.1759E-03	.2086E-03	.2086E-03
82.56	.7082	.6271	.6980	1.7519	.0255	.1755E-03	.2082E-03	.2082E-03
134.69	.5934	.6271	.6980	1.7519	.0095	.1751E-03	.2079E-03	.2079E-03
219.75	.5068	.6271	.6980	1.7519	.0027	.1749E-03	.2077E-03	.2077E-03
358.52	.4406	.6271	.6980	1.7519	.0006	.1748E-03	.2076E-03	.2076E-03
584.94	.3915	.6271	.6980	1.7519	.0001	.1748E-03	.2076E-03	.2076E-03

MODE NUMBER 1 SERIES RATE = 1.2091 CM/SEC PARALLEL RATE = 1.1214 CM/SEC BETAR = .2593

DZERO (MICRONS)	RATE (CM/SEC)	XNUV	ALFAV	RHOV (G/CM**3)	FSKP	XLAMAP (CAL/CM-S-K)	XLAMPF (CAL/CM-S-K)	XLAMFF (CAL/CM-S-K)
49.29	.8636	.6271	.6980	1.7519	.0006	.1760E-03	.2086E-03	.2086E-03
59.03	.8054	.6271	.6980	1.7519	.0036	.1758E-03	.2085E-03	.2085E-03
70.68	.7513	.6271	.6980	1.7519	.0169	.1756E-03	.2083E-03	.2083E-03
84.63	.7016	.6271	.6980	1.7519	.0602	.1755E-03	.2082E-03	.2082E-03
101.34	.6563	.6271	.6980	1.7519	.1615	.1753E-03	.2081E-03	.2081E-03
121.35	.6153	.6271	.6980	1.7519	.3259	.1752E-03	.2080E-03	.2080E-03
145.31	.5783	.6271	.6980	1.7519	.4383	.1751E-03	.2079E-03	.2079E-03
174.00	.5450	.6271	.6980	1.7519	.5744	.1750E-03	.2078E-03	.2078E-03
208.35	.5151	.6271	.6980	1.7519	.4939	.1749E-03	.2077E-03	.2077E-03
249.49	.4820	.6271	.6980	1.7519	.3263	.1748E-03	.2077E-03	.2077E-03
298.74	.4634	.6271	.6980	1.7519	.1615	.1748E-03	.2076E-03	.2076E-03
357.73	.4409	.6271	.6980	1.7519	.0602	.1748E-03	.2076E-03	.2076E-03
428.35	.4204	.6271	.6980	1.7519	.0163	.1748E-03	.2076E-03	.2076E-03
512.92	.4025	.6271	.6980	1.7519	.0036	.1748E-03	.2076E-03	.2076E-03
614.19	.3880	.6271	.6980	1.7519	.0006	.1748E-03	.2076E-03	.2076E-03

MODE NUMBER 2 SERIES RATE = .5507 CM/SEC PARALLEL RATE = .5444 CM/SEC BETAR = 0.0000

***** ALUMINUM COMBUSTION PEM INPUT/OUTPUT PARAMETERS *****

DBARM-MEAN DIAMETER OF METAL	18.560 MICRONS	BETA-MASS FRACTION OF METAL	.1600
BETAC-POWER LAW BURNING RATE CONSTANT	.0040 CM**2/SEC	DELHR-METAL HEAT OF COMBUSTION	1800.00 CAL/GRAM
CPM-METAL SPECIFIC HEAT	.21400 CAL/GRAM-K	G-GRAVITATIONAL CONSTANT	980.00 CM/SEC**2
RHOM-METAL DENSITY (SOLID)	2.710 G/CM**3	RHOL-METAL DENSITY (LIQUID)	2.350 G/CM**3
TMELT-METAL MELTING TEMPERATURE (K)	933.0	DELC-COMBUSTION LAW DIAMETER EXPONENT	2.00
TSMELT-METAL OXIDE MELTING TEMP. (K)	2320.0	IALST-NUMBER OF STEPS-EMERGENCE	100
GSUR-SURFACE TENSION	0.00 CM/SEC**2	IMET-NUMBER OF STEPS IN METAL INTEGRATION	30

DZERO (MICRONS)	RATE (CM/SEC)	VG (CM/SEC)	DAGGL (MICRONS)	TIGN (MSEC)	XIGN (MICRONS)	DLOFF (MICRONS)	VELF (CM/SEC)	TCOMB (MSEC)	XCOMB (MICRONS)	TSAL (PC)
.62	1.9518	27.05	19.46	.104	2.68	19.46	5.16	.947	165.98	5.641
1.01	1.9287	26.90	19.46	.104	2.69	19.46	5.15	.947	165.13	5.685
1.64	1.8909	26.64	19.46	.105	2.71	19.46	5.14	.947	163.65	5.761
2.68	1.8229	26.20	19.46	.107	2.75	19.46	5.13	.947	161.09	5.898
4.38	1.6814	24.98	19.46	.112	2.86	19.46	5.08	.947	154.07	6.295
7.14	1.5511	23.92	19.46	-.000	-.00	19.46	0.00	.947	127.77	8.725
11.65	1.3949	22.59	19.46	-.000	-.00	19.46	0.00	.947	120.11	9.324
19.01	1.2175	20.99	19.46	-.000	-.00	19.46	0.00	.947	110.93	10.109
31.01	1.0303	19.17	19.46	-.000	-.00	19.46	0.00	.947	100.50	11.092
50.60	.8551	17.34	19.45	-.162	-.19	19.46	0.00	.947	89.97	12.206
82.56	.7082	15.76	19.46	-.178	-.19	19.46	0.00	.947	81.03	13.209
134.63	.5934	14.57	19.46	-.193	-.19	19.46	0.00	.947	74.33	14.004
219.75	.5068	13.85	19.46	-.203	-.19	19.45	0.00	.947	70.30	14.499
358.52	.4406	13.60	19.46	-.206	-.19	19.46	0.00	.947	68.93	14.670
584.94	.3915	13.62	19.46	-.206	-.19	19.49	0.00	.947	69.03	14.658
49.29	.8638	17.44	19.46	-.161	-.19	19.46	0.00	.947	90.50	12.149
59.03	.8054	16.81	19.46	-.167	-.19	19.46	0.00	.947	86.95	12.537
70.63	.7513	16.23	19.46	-.173	-.19	19.46	0.00	.947	83.65	12.908
84.63	.7016	15.69	19.46	-.179	-.19	19.46	0.00	.947	80.63	13.255
101.34	.6563	15.21	19.49	-.185	-.19	19.46	0.00	.947	77.92	13.574
121.35	.6153	14.78	19.46	-.190	-.19	19.46	0.00	.947	75.54	13.857
145.31	.5783	14.42	19.46	-.195	-.19	19.46	0.00	.947	73.52	14.102
174.00	.5450	14.13	19.46	-.199	-.19	19.46	0.00	.947	71.87	14.304
208.35	.5151	13.90	19.46	-.202	-.19	19.46	0.00	.947	70.60	14.461
249.49	.4880	13.74	19.46	-.204	-.19	19.46	0.00	.947	69.71	14.573
298.74	.4634	13.65	19.46	-.206	-.19	19.46	0.00	.947	69.17	14.640
357.73	.4409	13.60	19.46	-.206	-.19	19.46	0.00	.947	68.93	14.670
428.35	.4204	13.60	19.46	-.206	-.19	19.46	0.00	.947	68.92	14.671
512.92	.4025	13.62	19.46	-.206	-.19	19.46	0.00	.947	69.00	14.661
614.19	.3890	13.62	19.46	-.206	-.19	19.46	0.00	.947	69.01	14.660

*** ZELDOVICH/NOVOZHILOV PRESSURE COUPLED RESPONSE CALCULATIONS ***

	DZERO (MICRONS)	PXK	PXR	PXN	PXM	PXD	PXS	ES1	ES2
1	.618	.5654E+00	.6491E-01	.7309E+00	.8335E-01	.3201E-03	.6749E-01	26923.61	26741.93
2	1.008	.5650E+00	.6501E-01	.7215E+00	.8219E-01	.4714E-03	.6752E-01	26939.65	26668.95
3	1.645	.5642E+00	.6513E-01	.7056E+00	.8023E-01	.6907E-03	.6754E-01	26966.32	26561.01
4	2.683	.5623E+00	.6521E-01	.6783E+00	.7668E-01	.1003E-02	.6752E-01	27015.15	26402.79
5	4.377	.5358E+00	.6245E-01	.6245E+00	.7028E-01	.1340E-02	.6489E-01	27096.43	26165.17
6	7.142	.7744E+00	.9100E-01	.5425E+00	.6021E-01	.2740E-02	.9452E-01	27376.02	25856.67
7	11.652	.9310E+00	.1106E+00	.4698E+00	.5090E-01	.4583E-02	.1148E+00	27909.77	25445.60
8	19.010	.9823E+00	.1185E+00	.4053E+00	.4216E-01	.6624E-02	.1227E+00	28898.92	24914.23
9	31.015	.1020E+01	.1256E+00	.3566E+00	.3484E-01	.9217E-02	.1296E+00	30537.56	24251.02
10	50.601	.1107E+01	.1398E+00	.3310E+00	.2935E-01	.1325E-01	.1430E+00	32835.42	23436.07
11	82.556	.1255E+01	.1645E+00	.3260E+00	.2679E-01	.2002E-01	.1649E+00	35771.02	22419.44
12	134.691	.1454E+01	.2012E+00	.3402E+00	.2540E-01	.3153E-01	.1937E+00	39139.47	21110.46
13	219.750	.1662E+01	.2492E+00	.3691E+00	.2529E-01	.4995E-01	.2233E+00	42493.05	19413.63
14	358.525	.1809E+01	.2995E+00	.3999E+00	.2704E-01	.7085E-01	.2439E+00	43000.20	17563.37
15	584.939	.1999E+01	.3279E+00	.3783E+00	.3427E-01	.3570E-01	.2694E+00	32141.69	17726.47
16	49.294	.1101E+01	.1388E+00	.3318E+00	.3006E-01	.1298E-01	.1421E+00	32697.32	23484.11
17	59.037	.1147E+01	.1465E+00	.3276E+00	.2873E-01	.1501E-01	.1491E+00	33682.05	23141.48
18	70.660	.1203E+01	.1556E+00	.3260E+00	.2764E-01	.1749E-01	.1572E+00	34746.42	22768.61
19	84.635	.1265E+01	.1663E+00	.3269E+00	.2677E-01	.2049E-01	.1664E+00	35690.49	22360.95
20	101.344	.1335E+01	.1786E+00	.3302E+00	.2605E-01	.2414E-01	.1765E+00	37108.07	21913.19
21	121.352	.1409E+01	.1925E+00	.3359E+00	.2560E-01	.2657E-01	.1872E+00	38383.29	21419.50
22	145.311	.1487E+01	.2080E+00	.3438E+00	.2529E-01	.3390E-01	.1984E+00	39688.82	20874.16
23	174.000	.1565E+01	.2250E+00	.3538E+00	.2517E-01	.4023E-01	.2095E+00	40980.24	20273.04
24	208.353	.1639E+01	.2433E+00	.3654E+00	.2523E-01	.4756E-01	.2201E+00	42178.89	19616.85
25	249.488	.1706E+01	.2623E+00	.3780E+00	.2550E-01	.5567E-01	.2295E+00	43135.46	18917.48
26	298.745	.1762E+01	.2814E+00	.3902E+00	.2604E-01	.6390E-01	.2374E+00	43570.64	18209.60
27	357.726	.1809E+01	.2993E+00	.3938E+00	.2702E-01	.7079E-01	.2438E+00	43015.82	17570.32
28	428.352	.1855E+01	.3145E+00	.4033E+00	.2870E-01	.7358E-01	.2500E+00	40846.02	17148.33
29	512.922	.1921E+01	.3248E+00	.3953E+00	.3142E-01	.5800E-01	.2588E+00	36560.60	17194.90
30	614.188	.2037E+01	.3278E+00	.3699E+00	.3551E-01	.4894E-01	.2745E+00	30291.55	18067.00

NDF	OMEGA (CPS)	RE(RSP/N)	IM(RSP/N)	RE(RSP)	IM(RSP)	MAG(RSP)	PHASE (DEGREES)	MAG(RSP/N)
.961E-01	.100E+02	.102E+01	.133E+00	.408E+00	.537E-01	.412E+00	.749E+01	.102E+01
.104E+00	.108E+02	.102E+01	.143E+00	.409E+00	.577E-01	.413E+00	.802E+01	.103E+01
.112E+00	.117E+02	.102E+01	.154E+00	.410E+00	.619E-01	.415E+00	.859E+01	.103E+01
.121E+00	.126E+02	.102E+01	.165E+00	.411E+00	.665E-01	.417E+00	.919E+01	.104E+01
.131E+00	.136E+02	.103E+01	.177E+00	.413E+00	.714E-01	.419E+00	.982E+01	.104E+01
.141E+00	.147E+02	.103E+01	.190E+00	.414E+00	.766E-01	.421E+00	.105E+02	.105E+01
.152E+00	.158E+02	.103E+01	.204E+00	.416E+00	.821E-01	.424E+00	.112E+02	.105E+01
.164E+00	.171E+02	.104E+01	.219E+00	.417E+00	.880E-01	.426E+00	.119E+02	.106E+01
.178E+00	.185E+02	.104E+01	.234E+00	.419E+00	.942E-01	.430E+00	.127E+02	.107E+01
.192E+00	.200E+02	.105E+01	.251E+00	.421E+00	.101E+00	.433E+00	.135E+02	.108E+01
.207E+00	.215E+02	.105E+01	.268E+00	.424E+00	.108E+00	.437E+00	.143E+02	.109E+01
.224E+00	.233E+02	.106E+01	.287E+00	.426E+00	.115E+00	.442E+00	.152E+02	.110E+01
.241E+00	.251E+02	.107E+01	.307E+00	.429E+00	.123E+00	.447E+00	.160E+02	.111E+01
.261E+00	.271E+02	.107E+01	.328E+00	.432E+00	.132E+00	.452E+00	.170E+02	.112E+01
.281E+00	.293E+02	.108E+01	.350E+00	.436E+00	.141E+00	.458E+00	.179E+02	.114E+01
.304E+00	.316E+02	.109E+01	.374E+00	.440E+00	.150E+00	.465E+00	.189E+02	.116E+01
.328E+00	.341E+02	.110E+01	.399E+00	.444E+00	.161E+00	.472E+00	.199E+02	.117E+01
.354E+00	.369E+02	.112E+01	.426E+00	.449E+00	.171E+00	.480E+00	.209E+02	.119E+01
.383E+00	.398E+02	.113E+01	.455E+00	.454E+00	.183E+00	.489E+00	.220E+02	.122E+01
.413E+00	.430E+02	.114E+01	.486E+00	.459E+00	.195E+00	.499E+00	.230E+02	.124E+01
.446E+00	.464E+02	.116E+01	.518E+00	.466E+00	.208E+00	.510E+00	.241E+02	.127E+01
.482E+00	.501E+02	.118E+01	.553E+00	.473E+00	.223E+00	.522E+00	.252E+02	.130E+01
.520E+00	.541E+02	.119E+01	.591E+00	.481E+00	.238E+00	.536E+00	.263E+02	.133E+01
.561E+00	.584E+02	.122E+01	.631E+00	.489E+00	.254E+00	.551E+00	.274E+02	.137E+01
.606E+00	.631E+02	.124E+01	.674E+00	.499E+00	.271E+00	.568E+00	.285E+02	.141E+01
.655E+00	.681E+02	.127E+01	.721E+00	.511E+00	.290E+00	.587E+00	.296E+02	.146E+01
.707E+00	.736E+02	.130E+01	.771E+00	.524E+00	.310E+00	.609E+00	.307E+02	.151E+01
.763E+00	.794E+02	.134E+01	.826E+00	.539E+00	.332E+00	.633E+00	.317E+02	.157E+01
.824E+00	.858E+02	.138E+01	.885E+00	.556E+00	.356E+00	.660E+00	.326E+02	.164E+01
.890E+00	.926E+02	.143E+01	.950E+00	.577E+00	.382E+00	.692E+00	.335E+02	.172E+01
.961E+00	.100E+03	.150E+01	.102E+01	.602E+00	.410E+00	.728E+00	.343E+02	.181E+01
.104E+01	.108E+03	.157E+01	.110E+01	.633E+00	.440E+00	.771E+00	.348E+02	.192E+01
.112E+01	.117E+03	.167E+01	.118E+01	.673E+00	.473E+00	.823E+00	.351E+02	.205E+01
.121E+01	.126E+03	.180E+01	.124E+01	.724E+00	.499E+00	.879E+00	.346E+02	.219E+01
.131E+01	.136E+03	.195E+01	.130E+01	.783E+00	.524E+00	.942E+00	.338E+02	.234E+01
.141E+01	.147E+03	.212E+01	.134E+01	.854E+00	.541E+00	.101E+01	.323E+02	.251E+01
.152E+01	.158E+03	.233E+01	.135E+01	.935E+00	.545E+00	.108E+01	.302E+02	.269E+01
.164E+01	.171E+03	.255E+01	.132E+01	.102E+01	.530E+00	.115E+01	.274E+02	.287E+01
.178E+01	.185E+03	.277E+01	.123E+01	.111E+01	.495E+00	.122E+01	.240E+02	.303E+01
.192E+01	.200E+03	.297E+01	.109E+01	.119E+01	.437E+00	.127E+01	.201E+02	.316E+01
.207E+01	.215E+03	.314E+01	.896E+00	.126E+01	.360E+00	.131E+01	.159E+02	.326E+01
.224E+01	.233E+03	.326E+01	.673E+00	.131E+01	.271E+00	.134E+01	.117E+02	.332E+01
.241E+01	.251E+03	.332E+01	.435E+00	.133E+01	.175E+00	.135E+01	.747E+01	.335E+01
.261E+01	.271E+03	.333E+01	.200E+00	.134E+01	.804E-01	.134E+01	.344E+01	.333E+01
.281E+01	.293E+03	.329E+01	-.180E-01	.132E+01	-.725E-02	.132E+01	-.314E+00	.329E+01
.304E+01	.316E+03	.321E+01	-.210E+00	.129E+01	-.843E-01	.129E+01	-.373E+01	.322E+01
.328E+01	.341E+03	.311E+01	-.370E+00	.125E+01	-.149E+00	.126E+01	-.679E+01	.313E+01
.354E+01	.369E+03	.299E+01	-.498E+00	.120E+01	-.200E+00	.122E+01	-.945E+01	.303E+01
.383E+01	.398E+03	.286E+01	-.595E+00	.115E+01	-.239E+00	.118E+01	-.117E+02	.293E+01
.413E+01	.430E+03	.274E+01	-.664E+00	.110E+01	-.267E+00	.113E+01	-.136E+02	.282E+01
.446E+01	.464E+03	.262E+01	-.710E+00	.105E+01	-.286E+00	.109E+01	-.152E+02	.271E+01
.482E+01	.501E+03	.250E+01	-.737E+00	.101E+01	-.299E+00	.105E+01	-.164E+02	.261E+01
.520E+01	.541E+03	.240E+01	-.748E+00	.965E+00	-.301E+00	.101E+01	-.173E+02	.251E+01
.561E+01	.584E+03	.230E+01	-.747E+00	.927E+00	-.301E+00	.974E+00	-.180E+02	.242E+01
.606E+01	.631E+03	.222E+01	-.738E+00	.893E+00	-.297E+00	.941E+00	-.184E+02	.234E+01
.655E+01	.681E+03	.214E+01	-.723E+00	.863E+00	-.291E+00	.910E+00	-.186E+02	.226E+01

.707E+01	.736E+03	.208E+01	-.704E+00	.836E+00	-.283E+00	.863E+00	-.187E+02	.220E+01
.763E+01	.794E+03	.202E+01	-.683E+00	.813E+00	-.275E+00	.859E+00	-.187E+02	.213E+01
.824E+01	.858E+03	.197E+01	-.662E+00	.793E+00	-.265E+00	.837E+00	-.185E+02	.208E+01
.890E+01	.926E+03	.193E+01	-.640E+00	.778E+00	-.258E+00	.818E+00	-.184E+02	.203E+01
.961E+01	.100E+04	.189E+01	-.620E+00	.761E+00	-.249E+00	.801E+00	-.182E+02	.199E+01
.104E+02	.108E+04	.186E+01	-.602E+00	.747E+00	-.242E+00	.785E+00	-.179E+02	.195E+01
.112E+02	.117E+04	.183E+01	-.585E+00	.735E+00	-.235E+00	.772E+00	-.177E+02	.192E+01
.121E+02	.126E+04	.180E+01	-.570E+00	.724E+00	-.229E+00	.760E+00	-.176E+02	.189E+01
.131E+02	.136E+04	.178E+01	-.558E+00	.715E+00	-.224E+00	.749E+00	-.174E+02	.186E+01
.141E+02	.147E+04	.175E+01	-.548E+00	.705E+00	-.220E+00	.739E+00	-.173E+02	.184E+01
.152E+02	.158E+04	.173E+01	-.540E+00	.696E+00	-.217E+00	.729E+00	-.173E+02	.181E+01
.164E+02	.171E+04	.171E+01	-.533E+00	.689E+00	-.215E+00	.720E+00	-.173E+02	.179E+01
.178E+02	.185E+04	.169E+01	-.529E+00	.679E+00	-.213E+00	.712E+00	-.174E+02	.177E+01
.192E+02	.200E+04	.167E+01	-.527E+00	.671E+00	-.212E+00	.703E+00	-.175E+02	.175E+01
.207E+02	.215E+04	.165E+01	-.525E+00	.662E+00	-.211E+00	.695E+00	-.177E+02	.173E+01
.224E+02	.233E+04	.162E+01	-.525E+00	.653E+00	-.211E+00	.686E+00	-.179E+02	.171E+01
.241E+02	.251E+04	.160E+01	-.526E+00	.644E+00	-.211E+00	.677E+00	-.182E+02	.168E+01
.261E+02	.271E+04	.158E+01	-.527E+00	.634E+00	-.212E+00	.668E+00	-.185E+02	.166E+01
.281E+02	.293E+04	.155E+01	-.529E+00	.624E+00	-.213E+00	.659E+00	-.188E+02	.164E+01
.304E+02	.316E+04	.153E+01	-.530E+00	.614E+00	-.213E+00	.650E+00	-.192E+02	.162E+01
.328E+02	.341E+04	.150E+01	-.532E+00	.603E+00	-.214E+00	.640E+00	-.195E+02	.159E+01
.354E+02	.369E+04	.147E+01	-.534E+00	.592E+00	-.215E+00	.630E+00	-.199E+02	.157E+01
.383E+02	.398E+04	.144E+01	-.535E+00	.581E+00	-.215E+00	.619E+00	-.203E+02	.154E+01
.413E+02	.430E+04	.142E+01	-.535E+00	.569E+00	-.215E+00	.609E+00	-.207E+02	.151E+01
.446E+02	.464E+04	.139E+01	-.535E+00	.558E+00	-.215E+00	.598E+00	-.211E+02	.149E+01
.482E+02	.501E+04	.136E+01	-.534E+00	.546E+00	-.215E+00	.587E+00	-.215E+02	.146E+01
.520E+02	.541E+04	.133E+01	-.533E+00	.534E+00	-.214E+00	.575E+00	-.219E+02	.143E+01
.561E+02	.584E+04	.130E+01	-.530E+00	.522E+00	-.213E+00	.564E+00	-.222E+02	.140E+01
.606E+02	.631E+04	.127E+01	-.527E+00	.510E+00	-.212E+00	.552E+00	-.226E+02	.137E+01
.655E+02	.681E+04	.124E+01	-.523E+00	.499E+00	-.210E+00	.541E+00	-.229E+02	.134E+01
.707E+02	.736E+04	.121E+01	-.519E+00	.487E+00	-.209E+00	.529E+00	-.232E+02	.132E+01
.763E+02	.794E+04	.118E+01	-.513E+00	.475E+00	-.206E+00	.518E+00	-.235E+02	.129E+01
.824E+02	.858E+04	.115E+01	-.507E+00	.464E+00	-.204E+00	.507E+00	-.237E+02	.126E+01
.890E+02	.926E+04	.113E+01	-.501E+00	.453E+00	-.201E+00	.495E+00	-.240E+02	.123E+01
.961E+02	.100E+05	.110E+01	-.494E+00	.442E+00	-.199E+00	.484E+00	-.242E+02	.120E+01
.104E+03	.108E+05	.107E+01	-.486E+00	.431E+00	-.196E+00	.473E+00	-.244E+02	.118E+01
.112E+03	.117E+05	.105E+01	-.478E+00	.421E+00	-.192E+00	.462E+00	-.246E+02	.115E+01
.121E+03	.126E+05	.102E+01	-.470E+00	.410E+00	-.189E+00	.452E+00	-.247E+02	.112E+01
.131E+03	.136E+05	.996E+00	-.461E+00	.400E+00	-.185E+00	.441E+00	-.249E+02	.110E+01
.141E+03	.147E+05	.972E+00	-.452E+00	.391E+00	-.182E+00	.431E+00	-.250E+02	.107E+01
.152E+03	.158E+05	.948E+00	-.443E+00	.381E+00	-.178E+00	.421E+00	-.250E+02	.105E+01
.164E+03	.171E+05	.926E+00	-.434E+00	.372E+00	-.174E+00	.411E+00	-.251E+02	.102E+01
.178E+03	.185E+05	.904E+00	-.424E+00	.364E+00	-.171E+00	.402E+00	-.252E+02	.998E+00
.192E+03	.200E+05	.883E+00	-.415E+00	.355E+00	-.167E+00	.392E+00	-.252E+02	.975E+00
.207E+03	.215E+05	.862E+00	-.405E+00	.347E+00	-.163E+00	.383E+00	-.252E+02	.952E+00
.224E+03	.233E+05	.842E+00	-.396E+00	.339E+00	-.159E+00	.374E+00	-.252E+02	.930E+00
.241E+03	.251E+05	.823E+00	-.386E+00	.331E+00	-.155E+00	.366E+00	-.251E+02	.909E+00
.261E+03	.271E+05	.804E+00	-.376E+00	.323E+00	-.151E+00	.357E+00	-.251E+02	.888E+00
.281E+03	.293E+05	.786E+00	-.367E+00	.316E+00	-.148E+00	.349E+00	-.250E+02	.867E+00
.304E+03	.316E+05	.768E+00	-.357E+00	.309E+00	-.144E+00	.341E+00	-.249E+02	.847E+00
.328E+03	.341E+05	.752E+00	-.348E+00	.302E+00	-.140E+00	.333E+00	-.248E+02	.828E+00
.354E+03	.369E+05	.735E+00	-.339E+00	.296E+00	-.136E+00	.326E+00	-.247E+02	.809E+00
.383E+03	.398E+05	.719E+00	-.330E+00	.289E+00	-.133E+00	.318E+00	-.246E+02	.791E+00
.413E+03	.430E+05	.704E+00	-.320E+00	.283E+00	-.129E+00	.311E+00	-.245E+02	.774E+00
.446E+03	.464E+05	.689E+00	-.312E+00	.277E+00	-.125E+00	.304E+00	-.243E+02	.757E+00
.482E+03	.501E+05	.675E+00	-.303E+00	.272E+00	-.122E+00	.298E+00	-.242E+02	.740E+00
.520E+03	.541E+05	.661E+00	-.294E+00	.266E+00	-.118E+00	.291E+00	-.240E+02	.724E+00
.561E+03	.584E+05	.648E+00	-.286E+00	.261E+00	-.115E+00	.285E+00	-.238E+02	.708E+00
.606E+03	.631E+05	.635E+00	-.277E+00	.256E+00	-.112E+00	.279E+00	-.236E+02	.693E+00
.655E+03	.681E+05	.623E+00	-.269E+00	.251E+00	-.108E+00	.273E+00	-.234E+02	.679E+00

.707E+03	.736E+05	.611E+00	-.261E+00	.246E+00	-.105E+00	.267E+00	-.232E+02	.664E+00
.763E+03	.794E+05	.599E+00	-.253E+00	.241E+00	-.102E+00	.262E+00	-.229E+02	.651E+00
.824E+03	.858E+05	.588E+00	-.246E+00	.237E+00	-.968E-01	.256E+00	-.227E+02	.637E+00
.890E+03	.926E+05	.577E+00	-.238E+00	.232E+00	-.958E-01	.251E+00	-.224E+02	.625E+00
.961E+03	.100E+06	.567E+00	-.231E+00	.228E+00	-.929E-01	.246E+00	-.222E+02	.612E+00

BELOW ARE THE VALUES OF XPLOT

0	.1000E+02	.1026E+02	.1053E+02	.1080E+02	.1108E+02	.1136E+02	.1166E+02	.1196E+02	.1227E+02	.1259E+02
1	.1292E+02	.1325E+02	.1359E+02	.1395E+02	.1431E+02	.1468E+02	.1506E+02	.1545E+02	.1585E+02	.1626E+02
2	.1668E+02	.1711E+02	.1756E+02	.1801E+02	.1848E+02	.1896E+02	.1945E+02	.1995E+02	.2047E+02	.2100E+02
3	.2154E+02	.2210E+02	.2268E+02	.2326E+02	.2387E+02	.2448E+02	.2512E+02	.2577E+02	.2644E+02	.2712E+02
4	.2783E+02	.2855E+02	.2929E+02	.3005E+02	.3082E+02	.3162E+02	.3244E+02	.3328E+02	.3415E+02	.3503E+02
5	.3594E+02	.3687E+02	.3782E+02	.3881E+02	.3981E+02	.4084E+02	.4190E+02	.4299E+02	.4410E+02	.4524E+02
6	.4642E+02	.4762E+02	.4885E+02	.5012E+02	.5142E+02	.5275E+02	.5412E+02	.5552E+02	.5696E+02	.5843E+02
7	.5995E+02	.6150E+02	.6310E+02	.6473E+02	.6641E+02	.6813E+02	.6989E+02	.7171E+02	.7356E+02	.7547E+02
8	.7743E+02	.7943E+02	.8149E+02	.8360E+02	.8577E+02	.8799E+02	.9027E+02	.9261E+02	.9501E+02	.9747E+02
9	.1000E+03	.1026E+03	.1053E+03	.1080E+03	.1108E+03	.1136E+03	.1166E+03	.1196E+03	.1227E+03	.1259E+03
10	.1292E+03	.1325E+03	.1359E+03	.1395E+03	.1431E+03	.1468E+03	.1506E+03	.1545E+03	.1585E+03	.1626E+03
11	.1668E+03	.1711E+03	.1756E+03	.1801E+03	.1848E+03	.1896E+03	.1945E+03	.1995E+03	.2047E+03	.2100E+03
12	.2154E+03	.2210E+03	.2268E+03	.2326E+03	.2387E+03	.2448E+03	.2512E+03	.2577E+03	.2644E+03	.2712E+03
13	.2783E+03	.2855E+03	.2929E+03	.3005E+03	.3082E+03	.3162E+03	.3244E+03	.3328E+03	.3415E+03	.3503E+03
14	.3594E+03	.3687E+03	.3782E+03	.3881E+03	.3981E+03	.4084E+03	.4190E+03	.4299E+03	.4410E+03	.4524E+03
15	.4642E+03	.4762E+03	.4885E+03	.5012E+03	.5142E+03	.5275E+03	.5412E+03	.5552E+03	.5696E+03	.5843E+03
16	.5995E+03	.6150E+03	.6310E+03	.6473E+03	.6641E+03	.6813E+03	.6989E+03	.7171E+03	.7356E+03	.7547E+03
17	.7743E+03	.7943E+03	.8149E+03	.8360E+03	.8577E+03	.8799E+03	.9027E+03	.9261E+03	.9501E+03	.9747E+03
18	.1000E+04	.1026E+04	.1053E+04	.1080E+04	.1108E+04	.1136E+04	.1166E+04	.1196E+04	.1227E+04	.1259E+04
19	.1292E+04	.1325E+04	.1359E+04	.1395E+04	.1431E+04	.1468E+04	.1506E+04	.1545E+04	.1585E+04	.1626E+04
20	.1668E+04	.1711E+04	.1756E+04	.1801E+04	.1848E+04	.1896E+04	.1945E+04	.1995E+04	.2047E+04	.2100E+04
21	.2154E+04	.2210E+04	.2268E+04	.2326E+04	.2387E+04	.2448E+04	.2512E+04	.2577E+04	.2644E+04	.2712E+04
22	.2783E+04	.2855E+04	.2929E+04	.3005E+04	.3082E+04	.3162E+04	.3244E+04	.3328E+04	.3415E+04	.3503E+04
23	.3594E+04	.3687E+04	.3782E+04	.3881E+04	.3981E+04	.4084E+04	.4190E+04	.4299E+04	.4410E+04	.4524E+04
24	.4642E+04	.4762E+04	.4885E+04	.5012E+04	.5142E+04	.5275E+04	.5412E+04	.5552E+04	.5696E+04	.5843E+04
25	.5995E+04	.6150E+04	.6310E+04	.6473E+04	.6641E+04	.6813E+04	.6989E+04	.7171E+04	.7356E+04	.7547E+04
26	.7743E+04	.7943E+04	.8149E+04	.8360E+04	.8577E+04	.8799E+04	.9027E+04	.9261E+04	.9501E+04	.9747E+04
27	.1000E+05	.1026E+05	.1053E+05	.1080E+05	.1108E+05	.1136E+05	.1166E+05	.1196E+05	.1227E+05	.1259E+05
28	.1292E+05	.1325E+05	.1359E+05	.1395E+05	.1431E+05	.1468E+05	.1506E+05	.1545E+05	.1585E+05	.1626E+05
29	.1668E+05	.1711E+05	.1756E+05	.1801E+05	.1848E+05	.1896E+05	.1945E+05	.1995E+05	.2047E+05	.2100E+05
30	.2154E+05	.2210E+05	.2268E+05	.2326E+05	.2387E+05	.2448E+05	.2512E+05	.2577E+05	.2644E+05	.2712E+05
31	.2783E+05	.2855E+05	.2929E+05	.3005E+05	.3082E+05	.3162E+05	.3244E+05	.3328E+05	.3415E+05	.3503E+05
32	.3594E+05	.3687E+05	.3782E+05	.3881E+05	.3981E+05	.4084E+05	.4190E+05	.4299E+05	.4410E+05	.4524E+05
33	.4642E+05	.4762E+05	.4885E+05	.5012E+05	.5142E+05	.5275E+05	.5412E+05	.5552E+05	.5696E+05	.5843E+05
34	.5995E+05	.6150E+05	.6310E+05	.6473E+05	.6641E+05	.6813E+05	.6989E+05	.7171E+05	.7356E+05	.7547E+05
35	.7743E+05	.7943E+05	.8149E+05	.8360E+05	.8577E+05	.8799E+05	.9027E+05	.9261E+05	.9501E+05	.9747E+05
36	.1000E+06									

BELOW ARE THE VALUES OF YPLOT

0	.1015E+01	.1016E+01	.1017E+01	.1017E+01	.1018E+01	.1019E+01	.1020E+01	.1021E+01	.1022E+01	.1023E+01
1	.1024E+01	.1025E+01	.1026E+01	.1027E+01	.1028E+01	.1029E+01	.1030E+01	.1032E+01	.1033E+01	.1034E+01
2	.1035E+01	.1037E+01	.1039E+01	.1040E+01	.1042E+01	.1044E+01	.1046E+01	.1047E+01	.1049E+01	.1051E+01
3	.1053E+01	.1055E+01	.1058E+01	.1060E+01	.1062E+01	.1064E+01	.1067E+01	.1069E+01	.1072E+01	.1075E+01
4	.1078E+01	.1080E+01	.1083E+01	.1087E+01	.1090E+01	.1093E+01	.1096E+01	.1100E+01	.1103E+01	.1107E+01
5	.1111E+01	.1115E+01	.1119E+01	.1123E+01	.1128E+01	.1132E+01	.1137E+01	.1142E+01	.1147E+01	.1152E+01
6	.1158E+01	.1163E+01	.1169E+01	.1175E+01	.1181E+01	.1188E+01	.1195E+01	.1202E+01	.1209E+01	.1217E+01
7	.1224E+01	.1233E+01	.1241E+01	.1250E+01	.1260E+01	.1269E+01	.1280E+01	.1290E+01	.1302E+01	.1313E+01
8	.1326E+01	.1339E+01	.1353E+01	.1367E+01	.1382E+01	.1399E+01	.1418E+01	.1434E+01	.1454E+01	.1474E+01
9	.1497E+01	.1521E+01	.1546E+01	.1574E+01	.1605E+01	.1638E+01	.1674E+01	.1713E+01	.1755E+01	.1800E+01
10	.1846E+01	.1895E+01	.1947E+01	.2003E+01	.2061E+01	.2123E+01	.2188E+01	.2256E+01	.2326E+01	.2398E+01
11	.2471E+01	.2545E+01	.2620E+01	.2694E+01	.2767E+01	.2837E+01	.2906E+01	.2970E+01	.3031E+01	.3087E+01
12	.3138E+01	.3183E+01	.3222E+01	.3256E+01	.3282E+01	.3303E+01	.3318E+01	.3326E+01	.3328E+01	.3326E+01
13	.3317E+01	.3304E+01	.3286E+01	.3264E+01	.3239E+01	.3210E+01	.3178E+01	.3144E+01	.3108E+01	.3070E+01
14	.3030E+01	.2990E+01	.2948E+01	.2906E+01	.2864E+01	.2822E+01	.2780E+01	.2738E+01	.2697E+01	.2657E+01
15	.2617E+01	.2578E+01	.2540E+01	.2503E+01	.2467E+01	.2432E+01	.2398E+01	.2365E+01	.2334E+01	.2304E+01
16	.2274E+01	.2246E+01	.2219E+01	.2193E+01	.2168E+01	.2145E+01	.2122E+01	.2100E+01	.2079E+01	.2059E+01
17	.2040E+01	.2022E+01	.2005E+01	.1988E+01	.1973E+01	.1957E+01	.1943E+01	.1929E+01	.1916E+01	.1903E+01
18	.1891E+01	.1880E+01	.1868E+01	.1858E+01	.1847E+01	.1838E+01	.1828E+01	.1819E+01	.1810E+01	.1801E+01
19	.1793E+01	.1784E+01	.1776E+01	.1769E+01	.1761E+01	.1753E+01	.1746E+01	.1739E+01	.1731E+01	.1724E+01
20	.1717E+01	.1710E+01	.1703E+01	.1696E+01	.1689E+01	.1682E+01	.1674E+01	.1667E+01	.1660E+01	.1653E+01
21	.1645E+01	.1638E+01	.1631E+01	.1623E+01	.1615E+01	.1608E+01	.1600E+01	.1592E+01	.1584E+01	.1576E+01
22	.1568E+01	.1560E+01	.1551E+01	.1543E+01	.1534E+01	.1525E+01	.1517E+01	.1508E+01	.1499E+01	.1490E+01
23	.1481E+01	.1472E+01	.1462E+01	.1453E+01	.1444E+01	.1434E+01	.1425E+01	.1415E+01	.1405E+01	.1395E+01
24	.1386E+01	.1376E+01	.1367E+01	.1357E+01	.1347E+01	.1337E+01	.1327E+01	.1317E+01	.1308E+01	.1298E+01
25	.1288E+01	.1278E+01	.1268E+01	.1258E+01	.1249E+01	.1239E+01	.1229E+01	.1220E+01	.1210E+01	.1200E+01
26	.1191E+01	.1181E+01	.1172E+01	.1162E+01	.1153E+01	.1144E+01	.1134E+01	.1125E+01	.1116E+01	.1107E+01
27	.1098E+01	.1089E+01	.1080E+01	.1071E+01	.1063E+01	.1054E+01	.1046E+01	.1037E+01	.1029E+01	.1020E+01
28	.1012E+01	.1004E+01	.9955E+00	.9875E+00	.9795E+00	.9716E+00	.9637E+00	.9560E+00	.9483E+00	.9407E+00
29	.9331E+00	.9257E+00	.9183E+00	.9110E+00	.9037E+00	.8966E+00	.8895E+00	.8825E+00	.8755E+00	.8687E+00
30	.8619E+00	.8552E+00	.8485E+00	.8419E+00	.8354E+00	.8290E+00	.8226E+00	.8163E+00	.8101E+00	.8040E+00
31	.7979E+00	.7919E+00	.7859E+00	.7800E+00	.7742E+00	.7684E+00	.7627E+00	.7571E+00	.7515E+00	.7460E+00
32	.7406E+00	.7352E+00	.7299E+00	.7246E+00	.7194E+00	.7143E+00	.7092E+00	.7042E+00	.6992E+00	.6943E+00
33	.6894E+00	.6846E+00	.6799E+00	.6752E+00	.6705E+00	.6659E+00	.6614E+00	.6569E+00	.6525E+00	.6481E+00
34	.6438E+00	.6395E+00	.6353E+00	.6311E+00	.6270E+00	.6229E+00	.6188E+00	.6148E+00	.6109E+00	.6070E+00
35	.6031E+00	.5993E+00	.5956E+00	.5919E+00	.5882E+00	.5845E+00	.5810E+00	.5774E+00	.5739E+00	.5704E+00
36	.5670E+00									

361 1 0 1 .10000E+02 .10000E+06 0. .50000E+01 .47244E+01 .39370E+01

BELOW ARE THE VALUES OF XPLOT

0	.8000E+02	.1200E+03	.1600E+03	.2000E+03	.3000E+03

BELOW ARE THE VALUES OF YPLOT

0	.1710E+01	.2000E+01	.2230E+01	.2690E+01	.2860E+01

5 1 0 4 .10000E+02 .10000E+06 0. .50000E+01 .47244E+01 .39370E+01

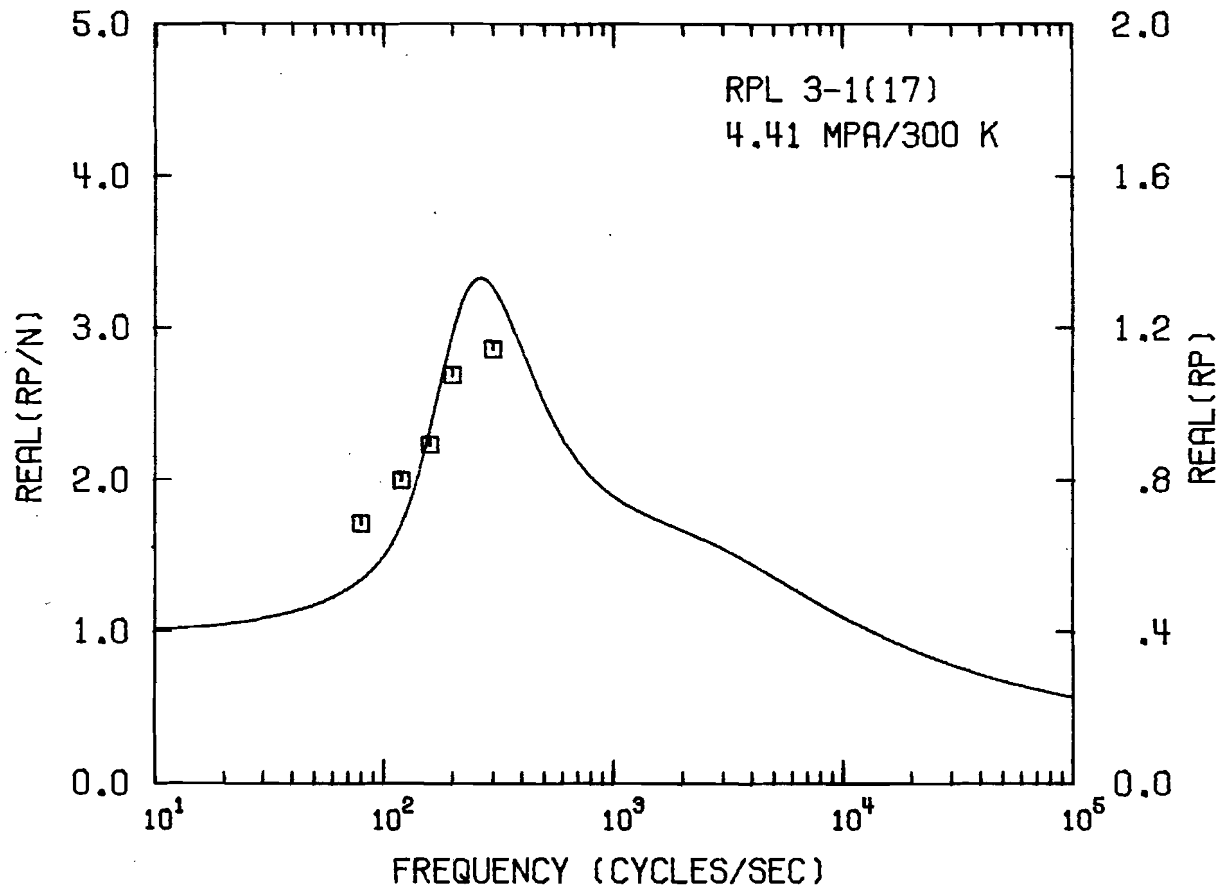

Figure 13. Pressure Coupled Response for Sample Case 10.